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Oil price shocks and its effect on the Brazilian, German, and Norwegian stock markets

By

Beatriz Chicas

Master in Finance

Supervisor

Júlio Fernando Seara Sequeira da Mota Lobão

Co-supervisor

Natércia Silva Fortuna

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Biographical Note

Beatriz Chicas was born in Corozal, Belize, on November 24th. In 2007 she was granted a Taiwan Scholarship, and successfully accomplished an MBA from National Tsinghua University in Taiwan. Later that year she started working as a lecturer in one of the junior colleges in Belize. In 2012 she was granted an Erasmus Mundus Scholarship and was admitted to pursue a Master degree in Finance at Universidade do Porto, Portugal; where she acquired valuable knowledge in areas such as Markets and Financial Investments, Econometrics, Corporate Finance, International Finance among others. Now she is looking forward to pursue a PhD in the same area of studies.

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"Lord, grant me the strength to accept the things I cannot change, the courage to change the things I can, and the wisdom to know the difference." ***Francis of Assisi***

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Beatriz Chicas

MF, FEP-UP

120417073@fep.up.pt

Abstract

Oil is a vital commodity; hence any changes in the price of oil have a significant impact on the economy. This dissertation analyses the relationship between oil price shocks and the stock market for Brazil, Germany and Norway by using monthly data from January 2003 to October 2013.

The methodology used follows very closely Sadorksy's (1999) paper whereby he focuses on the oil price shocks and its impact on real stock returns. Therefore, the Unrestricted Multivariate Vector Autoregression (VAR) with 4 economic variables (interest rates, changes in real oil prices, industrial production and real stock returns) is estimated as well as the impulse response function and variance decomposition.

The findings of this thesis are similar to Sadorsky's (1999) results. Whereby, oil price shocks have a significant impact on the stock market. Oil price shocks on Germany, an oil importing country, have negative effect on the stock market in the same month or in a short period of time. Brazil, an oil exporting country, shows a significantly negative effect on stock returns. Norway, on the other hand, also an oil exporting country, shows a significantly positive response of real stock returns to oil price shocks. An important result obtained was that the economic variables, that is, interest rates, changes in real oil prices, industrial production and real stock returns are influenced by movements in oil prices; vice-versa however is not the case.

Key-words: Stock Market, Vector Autoregression, Interest Rates, Oil Price Shocks,

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List of Acronyms used

ADF -	Augmented Dickey Fuller Test
AIC-	Akaike Information Criterion
BOVESPA -	Bolsa de Valores de São Paulo (São Paulo Stock Exchange)
CPI -	Consumer Price Index
DAX -	Deutscher Aktien Index (German stock index)
DF -	Dickey Fuller
FPE-	Final prediction error
GDP-	Gross Domestic Product
HQ -	Hannan-Quinn Information Criterion
IR-	Interest Rates
KPSS -	Kwiatkowski–Phillips–Schmidt–Shin
LIP-	Natural logarithms of industrial production
LO-	Real Oil Prices
LR -	Likelihood Ratio test
OECD-	Organisation for Economic Co-operation and Development
OLS -	Ordinary Least Squares
OSE-	Oslo Stock Exchange
RSR-	Real Stock Returns
SBC -	Schwarz Bayesian Criterion
SC -	Schwarz Information Criterion
UK -	United Kingdom
US -	United States
VAR -	Vector Autoregression (model)
VECM -	Vector Error Correction Model

1. Introduction to the research problem

During the past years oil prices have increase drastically. With countries like China and India becoming industrialized they have contributed in the increase of demand for oil. Oil is a scarce resource which means that there are no substitutes for oil regardless of high global demand for it. For the same reason, most research papers focus on the relationship between stock markets and oil prices particularly in the United States or European market as whole and Asian major stock markets.

This dissertation focuses on three specific countries following closely Sadorsky's (1999) research paper methodology. With the difference that Sadorsky only analysed United States monthly data starting from January 1947 to April 1996 giving a total of 49 years. Our dissertation however, analyses data for a period of 10 years from January 2003 to October 2013. Brazil and Norway which are oil exporting countries are both countries from different continents yet play a vital role in the oil industry. Data for Germany which is an oil importing country and has the largest national economy in Europe is also analysed.

It is essential to look at the history of oil in particular the periods where major changes in the prices of oil occurred since these changes had an impact not only on Brazil, Germany and Norway's economies but also in other countries' economies such as the United States. In 1988 China counted with approximately 6.3% compounded annual increase for consuming petroleum which is forecasted that if it continues at that pace by 2033 it would double the U.S present consumption of petroleum. Furthermore, China is considered as having the world's biggest market for purchasing new vehicles. Hence, the challenge as to whether the demand for petroleum to newly industrialized countries will be met is still a topic discussed for the past fifteen years.

During the 2007 and 2008 there was an increase in demand but supply was stagnant causing the prices of oil to increase. Hence, over the years prices of petroleum have been affected globally by factors such as recessions, changing of the industry and wars.

Furthermore, according to past literature changes in oil price have an asymmetric effect on the stock market. For instance, increases in oil prices have a larger impact on the stock market than when a decrease in oil price occurs. Therefore, the main focus of our dissertation will be the German, Brazilian and Norwegian stock market. The reason for choosing these three particular countries is that we had special interest in oil exporting and oil importing countries from different continents. Considering that Germany is an oil importing country and has one of the largest economies in the European market while Brazil and Norway are oil exporting countries; then it makes it interesting to know how these particular countries are being affected by the increase in oil prices and the recent economic crisis.

Hamilton's (1983) paper studies the influence of oil price shocks especially in the U.S. economy. This topic raised interest since there is limited literature on oil price volatility and its effect on the stock market. Past and present literature focuses mostly on developed economies such as the U.S. Therefore, there is still interest in the relationship between oil price changes and its effect on the stock market in particular economies. As a matter of fact, we will contribute to the existing literature with findings on these three countries.

The aim is to to identify whether increases in oil prices over the past ten years from 2003 to 2013 has a relationship on the three stock markets to be studied. The time period considered takes into account the Iraq war in 2003, and economic crises in 2008 onwards. These are periods where oil prices increased dramatically due to difficulties in supply with increases in demand globally.

Therefore, the researcher expects to identify the dynamic relationship between interest rates, oil prices, industrial production and real stock returns in these specific countries. Hence, the issues to be discussed in this dissertation are as follows: Identify the relationships between the four economic variables in the Brazilian stock market, Identify the relationships between the four economic variables in the German stock market; Identify the relationships between the four economic variables in the Norwegian stock market.

This dissertation will be structured as follows: Firstly, relevant literature and theoretical framework on the relation of oil price volatility and stock market along with oil prices and macroeconomic level is discussed. Secondly, we discuss the methodology used by previous studies made along with definitions pertaining to the relevant topic. The methodology used for the accomplishment of this dissertation is divided into three major sections following Sadorsky's (1999) paper. In this study the major model used is Unrestricted Multivariate Vector Autoregression (VAR) with the aim of identifying the relationship between the four economic variables (interest rates, oil prices, industrial production, and real stock returns) and oil price volatility. All findings and results are analysed in section four of this paper with section five concluding the dissertation.

2. Literature Review

In this section we will show the importance of what the past literature has studied with regards to the relationship of oil price increases and its effects on the economy. The literature review is divided into three parts. Section 2.1 deals with studies made on oil price and stock market while section 2.2 deals with studies that examine changes in oil prices and economic output. Lastly, section 2.3 looks at how various theories in relation to empirical evidence relate to the relationship between oil price shocks and the stock market.

2.1 Similar studies

Hamilton's (1983) paper studied the influence that an oil price shock has on the U.S economy. He used a seven-variable VAR system to analyse data and finds that after the World War II oil prices increase contributed to economic recession. Note that he clearly states that there is a statistically significant correlation between oil price shocks and economic recession which does not mean that oil price shocks was the cause for U.S. recession. Furthermore, Hamilton's (1983) paper finds that the correlation existing between increase in oil price and economic output for a period of twenty four years from 1948 to 1972 has nothing to do with historical chances. In fact, to prove that it did not happened by coincidence he pointed out that in the years 1973 to 1980 the same oil price changes occurred and these negative results varied during inflationary periods. Hamilton's (1983) paper created interest in studying more about this topic as a result several papers were published after that which are in accordance with Hamilton's (1983) findings.

For instance, Gisser and Goodwin (1986) studied the impact of oil price shocks on the U.S economy for a period of twenty one years from the first quarter of 1961 to fourth quarter of 1982 from which they tested for regime shift in 1973. Results showed that in 1973 after the Organization of the Petroleum Exporting Countries (OPEC, thereafter) started, the oil price impact on the U.S economy did not change. They found out that there is a relationship between changes in oil price and macroeconomic variables. Hence, oil price changes allowed growth in Gross National Product to be predicted. Furthermore, their results showed that after oil markets are disrupted the monetary and fiscal policy by itself cannot explain the impact oil price shocks has on the economy. As a matter of fact, they found out that oil shocks also affected the economy inflationary cost-push effects. Hooker (1996) run Granger causality tests and his results were in accordance with Hamilton's findings. Hooker analysed data from

1984 to 1972 and revealed that by increasing 10% in prices of oil it lead to approximately a 0.6 % growth in GDP which were lower in the third and fourth quarters after the shock.

Jones and Kaul (1996) are from the very first authors who used current and future changes in real cash flows or fluctuations in expected returns to investigate stock market in countries like U.S., Canada, U.K and Japan with the idea of taking into consideration environmental differences. They look at an international perspective to identify its reaction in relation to oil shocks. In their study through 1991 for U.S., Canada and Japan oil prices allowed to forecast stock returns while it was not the case for UK. Their results showed that on average the sudden oil price increase after the war had a significant effect on the stock market of the countries studied. Canada showed less of an important case while Japan showed more dramatic results.

Their study also showed that current and lagged oil prices variables affect stock returns in a negative way for U.S, Canada and Japan. As a matter of fact, the concluding outcome showed more significant negative results. For the same reason whether oil shocks bring across disparities in expected return or whether there are inefficiencies in the stock market is still a question. Taking into consideration errors in measurement for all economic variables, the authors highlights that, “the ‘true’ effects of oil shocks on stock returns are likely to be even stronger,” Jones and Kaul, (1996) pp. 472. The outcome indicated that the effects oil shock has on the U.S. and Canadian stock markets are with no doubt explained by their effects on current and future real cash flows. Furthermore, the fluctuations on the Japanese and UK stock market cannot be explained by real cash flows and expected returns. In fact, after the war oil price shocks seemed to have created volatility on these two countries stock market.

Sadorsky (1999) and Papapetrou (2001) are two authors that added knowledge to the studies of stock markets. Sadorsky analyzed U.S data on a monthly basis for forty-nine years starting from 1947 to 1996. Sadorsky (1999) and Papapetrou (2001) came up with the conclusion that oil price shocks have a negative and statistically significant initial impact on stock returns. As a matter of fact, earnings decreased since the higher the oil prices the higher the production cost. Efficient stock markets will respond immediate by showing a decline in stock prices. Hence, oil price shocks in particular weaken real stock returns. Sadorsky (1999) analyzed his data by dividing it into two periods. His results showed that after 1986 oil price shocks had a greater impact on real stock return. Therefore, there was a fairly change in dynamics rather than in the response of the system to these shocks. Papapetrou (2001) study found out that that real stock returns are negatively affected whereby its impact goes on for approximately four months.

Hung *et al*. (1996) found out that there is no impact on indexes with broad bases such as S&P 500 but by studying oil futures and stocks of individual companies he was able to provide evidence and support for significant causality from oil futures to stocks of particular companies. Hence, Ciner (2001) proved that crude oil futures and S&P 500 index returns have a significant nonlinear casual correlation. He goes into further detail and showed that stock index returns have an effect on oil price futures. By studying the relationship that exists between oil prices and the stock market Ciner (2001) expanded on Hamilton's (2003) work and tested for nonlinear linkages. He argued that there were not an adequate amount of nonlinear linkages. In fact, the analysis made for ten years from March 1990 to March 2000 demonstrated a stronger nonlinear relationship which in turn coincides with Sadorsky's (1999) argument.

In this section several studies are discussed. Authors such as Gisser and Goodwin (1986), Hooker (1996) agree on their findings since it reveals that there is a relationship between changes in oil price and macroeconomic variables. Sadorsky (1999) and Papapetrou (2001) on the other hand, contributed knowledge to the studies of stock markets. Ciner (2001) expanded on Hamilton's work while testing for nonlinear linkages.

2.2 Oil price changes and economic output

As discussed earlier, Hamilton's (1983) paper revealed that the correlation existing between increase in oil price and economic output for a period of twenty four years from 1948 to 1972 had nothing to do with historical chances. He emphasized that effect are more negative in particular during inflationary periods. He argued that a decrease in GNP cannot be predicted by relying only on economic activities such as output or money supply. Gisser and Goodwin (1986) investigated data from 1961 to 1982 and these authors concluded that with oil prices there is still the possibility of predicting growth in GNP. Based on their results they argued that oil shocks not only have an impact on economic output by inflationary cost-push effects but also by other means. Furthermore, when the OPEC period started in 1973 the oil price effects had no alteration.

Hamilton analyzed more data which included the oil price downfall in 1986. So he covered data until 1988. Mork (1989) on the other hand, took into consideration the real oil price and not the producer price index for crude oil since it just showed that prices are controlled. Hence, Mork (1989) performed refiner acquisition cost (RAC) from 1974 not only for domestic but also for imported crude oil. His results were in accordance with Hamilton's findings whereby a negative correlation is shown between output growth and oil price increases. The correlation showed was stronger than what was expected. In fact, a hypothetical linear relationship between changes in oil prices and economic growth would imply a stimulation of economic growth by an oil price decline. However, in the 1980s, economic output growth was slowed down by oil price changes although oil price declines occurred as well. Thus, Mork (1989) examined possible asymmetric effects of disruptions in the oil market. He analysed changes in oil prices with relation to increase and decrease in real price. The results revealed that the correlation with regards to decrease in price is significantly different and could even possibly be zero for the U.S. Furthermore, Mork (1989), and Olsen and Mysen (1994) study revealed that there is an asymmetry in effects when it comes to other Organisation for Economic Co-operation and Development (OECD) countries. When compared to other countries, increases in oil price appear to slow down growth particularly in the U.S. economic to a degree where even if this country turns into less dependent than countries like Germany, France, and Japan on imported oil it still suffers the consequences.

Lee *et al*. (1995) also showed the steadiness of asymmetric effects before and after 1985. In fact, Ferderer (1996) concentrated his study in three possible areas i.e. uncertainty, counter inflationary monetary policy and sectoral shocks. His study explained the asymmetric mechanism between the influence of changes in oil price and economic activity. Ferderer's findings revealed a significant relationship between increases in oil prices and reactions in counter inflationary policies. However, the study showed that increases in oil price help forecast output growth regardless of monetary policy variables. Furthermore, Ferderer (1996) showed that monetary policy measures in response to decreases in real oil prices closely resemble those for oil price increases. Therefore, asymmetric monetary policy responses can only clarify a portion of the relationship in asymmetric oil price-output. In fact, Balke *et al*. (2002) back up Ferderer by giving a similar explanation in relation to the asymmetric effects oil price shocks and its effect on macroeconomic activities. The authors suggested that monetary policy by itself cannot explain the real effects oil price shocks have on real GDP. Their research revealed that interest rates are a crucial mechanism through which oil prices affect economic output.

On the other hand, Rotemberg and Woodford (1996) took a different approach in identifying how it is that oil prices impact the economy when in reality oil being a factor of production represents a minimal part of the total marginal cost of production. Hence, their main focus was on private added value; the reason they subtracted government added value is because they argue that their theories of pricing and production decisions are not applicable to governmental demand. Hence, they used data for thirty-two years and incorporated the model to analyse the effects real wages and imperfectly competitive product market has. Their findings showed that private output does certainly decreases resulting in a positive innovation in prices of oil. As a matter of fact, a 1 percent increase in the prices of oil showed a negative 0.25 percent decrease in output after five-seven quarters. Rotemberg and Woodford (1996) discussed that after oil prices increase to approximately 10 percent; real wages would decrease by 1 percent that is after five or six quarters.

Additionally, Chaudhuri (2000) presented a crucial relationship between prices of oil and real prices of primary commodities. The investigation demonstrated that the non-stationary behaviour of real commodity prices is as a result of the non-stationary behaviour of real oil prices. It is important to consider that the impacts varied depending on the commodities in question regardless if oil was being directly used in the manufacturing of commodities. Through the impact of the oil price changes on real exchange rates this caused any alteration in the prices of oil to affect the prices of primary commodities.

Hamilton (1988) examined a general equilibrium model that deals with the business cycle model and unemployment. His results revealed that it is expensive to shift capital and labor inputs between sectors. Such model demonstrated that energy price shocks can decrease aggregate employment by encouraging laborers in unfavorable affected sectors to continue unemployed meanwhile they wait for labor conditions to improve in their sector, instead of moving to a sector that is not adversely affected.

Rotemberg and Woodford (1996) on the other hand, with an aggregative model studied the impact oil price shocks have on output and real wages. These authors assumed there was imperfect competition in the product market. Giving some space for imperfect competition such as agreements between oligopolies accounted for decreases in output of real wages after considering oil price shock. These authors focused their research on the U.S market and stated that an imperfect competition model can clarify the impact oil price shocks has on the U.S economy. According to them, an imperfect competition model can explain the impacts oil price shock has on the US economy into more detail than a stochastic growth model.

Finn (2000) argued that the effects of oil price shocks can be explained by using perfectly competitive models. He used the idea of rate utilization and energy services for a productive capital. Price shocks lead to decrease in energy use which in turn decreased the output in labor's marginal product. As a result, there was a decrease in wages and labor supplied. He believed that oil price shocks is like adverse technology shocks in promoting a contraction in economic activities.

Miguel *et al*. (2003) studied a small open economy for Spain in order to identify the impacts oil price shocks has at a macroeconomic level. In their model oil is considered to be an imported productive input while interest rates implicitly reflected the international market. They demonstrate that increases in oil prices have a negative and significant impact on welfare.

In this section authors such as, Gisser and Goodwin (1986) investigated data from 1961 to 1982 and concluded that with oil prices there is still the possibility of predicting growth in GNP. Rotemberg and Woodford (1996) on the other hand, took a different approach in identifying ways in which oil prices impact the economy. Their findings showed that private output does certainly decreases resulting in a positive innovation in prices of oil. Ferderer (1996) showed that monetary policy measures in response to decreases in real oil prices closely resemble those for oil price increases. As a matter of fact, Balke *et al*. (2002) back up Ferderer by giving a similar explanation in relation to the asymmetric effects oil price shocks and its effect on macroeconomic activities. The authors suggested that monetary policy by itself cannot explain the real effects oil price shocks have on real GDP.

2.3 Empirical evidence with particular theories on oil price shocks

Several theories are analyzed within this section along with empirical evidence. For instance, the standard growth theory main focus is based on primary inputs such as capital, labor and land. This theory fails to identify the important role that primary energy inputs such as oil deposits play. As a result, natural scientists and ecological economists have worked to change this theory so that it considers the role oil price volatility has on economic growth. Consequently, it integrates the relationship between energy resources and its accessibility and volatility on economic growth.

The mainstream theory of economic growth hypothesizes that production requiring energy is the most crucial factor for any economic growth. This theory classifies capital, labor and land as main factors of production; for the mere reason that they are present at the beginning of the production process and are indirectly used. Oil, fuel and gas which are considered energy resources are classified as intermediaries since they are produced and are entirely used up during the production process. While identifying the marginal product of oil in relation to energy resource the mainstream theory takes into account the ability of these energy resources to assist in production process and get the work done. Hence, the theory assesses the price at which crude oil should be sold whereby it's a price that is in accordance and proportion to its marginal product.

The Linear/Symmetric relationship theory of growth which is supported by Hamilton (1983), Gisser and Goodwin (1986) hypothesized that volatility in prices of oil determines volatility in the growth of Gross National Product (GNP). The theory is contingent with the impact oil market had during the years 1948 and 1972 on the economies of oil-exporting and oil-importing countries. Hooker (2002) conducted vast amount of empirical studies and proved that between 1948 and 1972 the level of oil prices and its fluctuations had a significant effect on the growth of Gross Domestic Product (GDP). Later, Laser (1987) verified the symmetric relationship that exists between volatility in oil price and economic growth. The study concluded that oil price increases requires a decrease in GDP. This however shows that the effect decreases in oil price has on decreases in GDP is vague since the effect varies from country to country.

The Asymmetry-in-effects theory of economic growth which was used as a case study by the U.S. economy suggests that the correlation existing between decreases in prices of crude oil and economic happenings in particular in the U.S economy is significantly different and possibly zero. Furthermore, Ferderer (1996) concentrated on three areas to explain the asymmetric effect that exists between volatility in oil prices and economic growth. His study was concentrated on uncertainty, counter-inflationary monetary policy and sectoral shocks. His findings reveal that there exists a significant relationship between oil price increases and responses to counter-inflationary policy. Balke (1998) agrees with Federer (1996) findings since he hypothesized that monetary policy by itself does not necessarily clarifies the real effects oil price volatility has on real Gross Domestic Product.

The Renaissance growth theory which was a branch of the symmetric and asymmetric effects lead Lee (1998) to distinguish volatility as the standard deviation for a given period of time. This author showed that volatility and standard deviation both have negative effects on economic growth. The effects however vary since volatility immediately shows a negative and significant effect on the economic growth while the effects of changes in oil prices slow down after a year. Lee (1998), concluded by saying that it is volatility in prices of crude oil rather than prices in oil level that has a significant effect on economic growth. In fact, theories such as the income transfer model of growth and the decoupling theory discusses oil price volatility and its impact on economic growth.

Furthermore, the economic theory states that changes in oil prices have an effect on the economic activities when it comes to supply and demand. Supply by itself is explained since oil is a crucial input in the production process. Hence, increases in oil prices will decrease the demand for oil causing a decrease in the production of other outputs; this will result in a decrease of inputs in a particular company. On the other hand, consumption is indirectly affected by the positive relationship with income. For instance, when oil price increases oil exporting countries transfer their income to oil importing countries. This causes consumption to decrease in the oil importing countries. As a matter of fact, increases in oil prices have a negative effect on investment since it increases cost. Moreover, increases in oil prices have a negative effect on investment by increasing the costs of a particular firm. Additionally, changes in oil prices could also affect the economy not only through inflation but also through foreign exchange markets.

In general, despite the fact that, the theories already discussed are ambiguous and lack econometric analysis they are related to each other and have the support from environmental, scientist, and ecological economists. These theories however, provide analysis and suggestions which contribute to our empirical studies.

3. Data and Research Methodology

In order to describe the data used and the methodology implemented this section is divided into two parts. Subsection (3.1), will present the main data and the sample that we have collected while subsection (3.2) will provide detail information with regards to the methodology and the steps followed in order to reach the final results.

3.1 Data

Our study is focused towards the Brazilian (BOVESPA), German (DAX 30), and Norwegian (OSE) stock market. Hence, this research paper expands on Sadorsky's (1999) research whereby he analysed U.S monthly data starting from January 1947 to April 1996 giving a total of 49 years. This research paper on the other hand, utilizes monthly data for a period of ten years with samples from January 2003 to October 2013 which gives a total of 130 observations. DataStream was utilized to gather the data. The variables utilized are the natural logarithms of industrial production (lip) which measure output of production, real oil prices (lo), T-bill rate (ir) and real stock returns (rsr) for Brazil, Germany and Norway. Real oil prices (lo) and real stock return (rsr) are calculated by the equation below:

$$Real\ oil\ prices = \frac{Producer\ price\ index\ of\ fuels}{Consumer\ price\ index} * 100 \tag{1}$$

$$Real\ stock\ returns = \Delta(\ Stock\ price\ index) - \Delta(Consumer\ price\ index) \tag{2}$$

Note that the data for consumer price index and producer price index are also gathered from DataStream. Note that Δ is calculated as the difference between today's price and last month's price. The VAR Model will be run using EViews in order to identify the effects oil price shocks has on real stock returns. Before applying the VAR model however, data needs to be tested whether they are stationery or non-stationery. In the case of non-stationery data a cointegration test needs to be conducted.

After applying the cointegration test, if the result reveal that the variables do not have long run relationship or are not cointegrated then this implies that the VAR model can be applied for all four economic variables which are Δlip, Δlo, Δlr and rsr. However, if there is a relationship among variables; in other words if cointegration exists then a Vector Error Correction Model (VECM) will be applied. Thereafter, a detailed explanation of VAR and

VECM is given by performing an impulse responses functions and variance decomposition analysis. Results and interpretations are given in detail in Chapter 4 of this dissertation.

EViews was used to analyse the data. Tables 1, 2 and 3 below show a summary of the descriptive analysis of data for Brazil, Germany and Norway.

Table 1 below shows that the logarithm of industrial production (lip) and real stock return (rsr), exhibit negative skewness. As a result, it can be implied that these two variables have asymmetric distribution with a longer left tail. Real oil prices (lo) and interest rates (ir) have an asymmetric distribution with a longer right tail.

Real stock return (rsr) has a high kurtosis. On the other hand, all variables have high Jarcque-Bera test statistics which states that the variables are not normally distributed and suggests the rejection of normality based on a p-value of 0.000.

Table 1: Brazil's variables summary of descriptive statistics

Brazil	**lip**	**lo**	**ir**	**rsr**
Mean	4.768077	14.67560	13.32477	317.4406
Median	4.795000	14.75112	12.09000	441.8150
Std. Dev.	0.082341	0.510375	4.763907	3092.262
Skewness	-0.732238	0.021103	1.029293	-0.565383
Kurtosis	2.562824	1.838376	3.728482	4.579778
Jarque-Bera	12.65231	7.318735	25.82919	20.44430
p-value	0.001789	0.025749	0.000002	0.000036

Source Eviews

Table 2 below shows that all series, with the exception interest rates (ir), exhibit negative skewness. It can be implied that the series logarithm of industrial production (lip), real oil prices (lo) and real stock returns (rsr) have an asymmetric distribution with a longer left tail, whereby series interest rate (ir) has an asymmetric distribution with a longer right tail. Most variable, with the exception of real stock return (rsr), have a high kurtosis. Real stock returns (rsr) on the other hand, has excess Kurtosis of 6.899. All variables have high Jarcque-Bera test statistics which states that the variables are not normally distributed and suggests the rejection of normality based on a p-value of 0.000.

Table 2: Germany's variables summary of descriptive statistics

Germany	lip	lo	ir	Rsr
Mean	4.601203	103.7631	2.105231	47.11154
Median	4.622025	105.4618	2.115000	101.5500
Std. Dev.	0.081446	17.39482	1.412090	317.6793
Skewness	-0.327530	-0.097813	0.554053	-1.338440
Kurtosis	1.609143	2.254286	2.338951	6.899460
Jarque-Bera	12.80277	3.219448	9.018133	121.1788
p-value	0.001659	0.199943	0.011009	0.00000

Source Eviews

Table 3 below shows that the logarithm of industrial production (lip) and real stock return (rsr) for Germany exhibit negative skewness. As a result, it can be implied that this two series have an asymmetric distribution with a longer left tail.

Most variables have a high kurtosis. All variables have high Jarcque-Bera test statistics which states that the variables are not normally distributed and suggests the rejection of normality based on a p-value of 0.000.

Table 3: Norway's variables summary of descriptive statistics

Norway	lip	lo	ir	rsr
Mean	4.686913	147.1682	3.142846	2.927923
Median	4.706824	141.9627	2.620000	7.575000
Std. Dev.	0.068625	38.44184	1.450187	20.38929
Skewness	-0.380152	0.096284	1.264982	-1.866587
Kurtosis	1.930322	1.711367	3.461905	9.798777
Jarque-Be	9.328972	9.195644	35.82622	325.8664
p-value	0.009424	0.010074	0.00000	0.00000

Source Eviews

3.2 Methodology

The methodology is divided into four sections. With each section explaining into detail all the methods used before attaining a conclusion.

3.2.1 Unit Root Test

A time series is considered stationary when not only the mean is constant but also its variance is constant over time. In fact, the covariance between the two variables is not dependent on the actual time observed but instead it depends on the lag length of time. For example, a simple auto-regression model of order one:

$$y_t = \rho y_{t-1} + \varepsilon_t \tag{3}$$

Whereby, ρ represents the parameter to be projected and ε_t represents an independent error which has a constant variance and zero mean. In this case when, |ρ|, which is the absolute parameter, is less than one then the model is considered to have a property of stationary. There are exceptions and in cases where |ρ|=1, the series is non–stationary. Hence, it is called a random walk type of model:

$$y_t = y_{t-1} + \varepsilon_t \tag{4}$$

For instance, in the equation above because this time series seems to roam either upward or downward in an unpredictably manner then it is considered to be a random walk model. When compared to stationary variables, a random walk series has a constant mean. The value of its variance however keeps increasing which eventually leads to infinite. Therefore, it can be implied that regardless of the constant mean, the series may not go back to its mean. In other words, the behaviour shows that the sample mean will be different unless considered and is taken from the same period.

Furthermore, random walk can be categorized in two different ways, random walk with drift which is represented by the equation $(y_t = \alpha + y_{t-1} + \varepsilon_t)$ and random walk with drift and a time trend which is represented by the following equation $(y_t = \alpha + \delta t + y_{t-1} + \varepsilon_t)$. Various tests are available which help to identify whether a series is a stationary or non-stationary. The most frequently used however, is the Dickey-Fuller test. This test mostly concentrates in identifying the value ρ, and whether its value is equal or less than one. The Dickey-Fuller model can be assimilated by subtracting y_{t-1} from the auto-regression model:

$$\Delta y_t = \gamma y_{t-1} + \varepsilon_t \tag{5}$$

In this case $\gamma = \rho - 1$ and $\Delta y_t = y_t - y_{t-1}$.

The hypotheses are as follows:

Ho: The series is non-stationary or contain a unit root: $\gamma = 0$

Ha: The series is stationary: $\gamma < 0$

The flaw about this test however is that it does not allow for autocorrelation in the error term this autocorrelation appears to happen more for the higher level of lag. The reason being is that it captures the full dynamic nature of the process. As a result, an extension of the Dickey-Fuller test is presented and is denoted as the Augmented Dickey-Fuller (ADF, thereafter) test which is presented by the equation below:

$$\Delta y_t = \alpha + \gamma y_{t-1} + \sum_l^n a_l \Delta y_{t-l} + \varepsilon_t \tag{6}$$

The equation above shows that the lagged first difference terms of the dependent variables are added. This is done in order to guarantee that there is no autocorrelation in the residuals. The hypotheses of this test are equivalent to the hypothesis used by Dickey-Fuller test. As a matter of fact, a unit root test that is normally used to support the Augmented Dickey-Fuller test (ADF) is the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test. This particular test is quite the same as the ADF, with the difference that the hypotheses used by the KPSS test are precisely the contrary of ADF test. Consequently, the KPSS test hypotheses are:

H_0: The series is stationary

H_a: The series has a unit root or non-stationary

This thesis will use ADF test as well as KPSS test to support the results, with Schwarz Information Criterion in order to identify the lag.

3.2.2 Cointegration

When there is a cointegration it is because a relation between variables displays a stationary linear combination that is regardless if the particular variables are non-stationary. Cointegrated relationships are perceived as long run equilibrium phenomenon this is because there are effects that appear in the long run regardless whether in the short run the variables are independent.

This dissertation uses the methods developed by Johansen (1991) in order to test for the cointegration.

For instance, assuming that a set of n non-stationary variables and consider a VAR with k lags:

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \cdots + \beta_k y_{t-k} + \epsilon_t \tag{7}$$

In this case, y is a $n \times 1$ vector variables, β is a $n \times n$ matrix parameter, and ϵ_t is a white noise disturbance.

In order to use the Johansen test, the VAR equation needs to be changed into a vector error correction model (VECM):

$$\Delta y_t = \prod y_{t-k} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \cdots + \Gamma_{k-1} \Delta y_{t-(k-1)} + \varepsilon_t \tag{8}$$

In this case, $\prod = (\sum_{i=1}^{k} \beta_i) - I_n$ and $\Gamma_i = \left(\sum_{j=1}^{i} \beta_j\right) - I_n$. (9)

I is the identity matrix, $\prod$ is the long run coefficient matrix, and Γ is the short run dynamic. Johansen test emphases are on identifying the $\prod$ matrix by looking at the rank via its eigenvalues (λ). The number of its eigenvalues which are significantly different from zero will determine the rank (r) of matrix (i.e. when the rank is significantly different from zero, it shows that the variables are cointegrated).

Before performing the Johansen test, it is crucial to select an adequate lag that can be obtained from the VAR equation. Empirical evidence has shown that the total number of lags resulting from the VAR has a high effect in deciding the results of the cointegrated test. Nevertheless, deducing a lag order is complex particularly if the order of the lag is too high. Hence, it will approve that the errors are white noise. In fact, it should be low enough to make an approximation.

Johansen method involves two test statistics; this is done to test for cointegration specifically the trace test and the maximum eigenvalue test. These tests are expressed as follows:

a) Trace test:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \tag{10}$$

A joint test with null and alternative hypothesis of:

Ho: Number of cointegration vectors ≤ r

Ha: Number of cointegration vectors > r

b) Maximum eigenvalue test:

$$\lambda_{(r,r+1)} = -T \ln(1 - \hat{\lambda}_{r+1}) \tag{11}$$

A distinct test for each eigenvalue with null and alternative hypothesis of:

Ho: Number of cointegration vectors = r

Ha: Number of cointegration vectors = r+1

The Trace test and the Maximum eigenvalue test both have the r representing the number of vectors that are cointegrated under the null hypothesis. $\hat{\lambda}$ is the projected value for the *i*th systematic eigenvalue from the $\prod$ matrix. From the equation it can be depicted that the larger the $\hat{\lambda}$, then the larger the test statistic which will result in a larger and more negative variable $\ln(1 - \hat{\lambda}_{r+1})$. Furthermore, a significant vector that is cointegrated is presented by a significantly non-zero eigenvalue. Johansen and Juselius (1990) presented the distribution test statistics which is non-standard with critical values. These are determined by the value of of $n - r$.

3.2.3 Vector Autoregressive Model (VAR)

Furthermore, the VAR being another econometrics tool that displays the interrelationship between stationary variables it is utilized when there is no cointegration and the variables are either stationary or non-stationary. When variables are non-stationary and are not cointegrated a VAR model is used to identify the interrelationship. On the other hand, if the variables are non-stationary but cointegrated then a VEC model is projected. The researcher will use both but the main focus is on the VAR model. This model contains endogenous variables which permits variables to be dependent on their lags. For example, a bivariate VAR which contains two variables, i.e. y_{1t} and y_{2t}, whereby each dependent variable is dependent on the grouping of lags, k, and error terms as shown in the equation below:

$$y_{1t} = \beta_{10} + \beta_{11}y_{1t-1} + \cdots + \beta_{1k}y_{1t-k} + \alpha_{11}y_{2t-1} + \cdots + \alpha_{1k}y_{2t-k} + \varepsilon_{1t} \tag{12}$$

$$y_{2t} = \beta_{20} + \beta_{21}y_{2t-1} + \cdots + \beta_{2k}y_{2t-k} + \alpha_{21}y_{1t-1} + \cdots + \alpha_{2k}y_{1t-k} + \varepsilon_{2t} \tag{13}$$

Where, ϵ_{it} is a white noise disturbance with $E(\varepsilon_{it}) = 0, (i = 1,2),\ E(\varepsilon_{1t}\varepsilon_{2t}) = 0.$

Furthermore, in order to show the statistically significance of the variables two methods from VAR are utilized. When identifying both methods, the order of the variables plays a crucial role. Hence, impulse response shows that the shocks occurring to a single variable have an effect on the dependent variable in the model.

The effects of the shock can be explained by analysing the variance decomposition. Variance decompositions analysis is slightly different with impulse responses in term of how the shocks are applied. Furthermore, variance decompositions analysis emphasizes on the forecast error variance and it also emphasize on the movement of the dependent variable this permits the sources of the volatility to be identified.

3.2.4. AR Roots Graph

In order to test for stability the AR Roots Graph was used. This type of graph shows the stationarity of the VAR model. For instance, if all roots have absolute value less than one and lie inside the unit circle then the values are considered to be stationery.

4. Empirical results and Interpretation

This section is divided into six parts with each part analyzing the data for Brazil, Germany and Norway. Section 4.1 uses the unit root test to identify whether the data is stationery or non-stationery.

Section 4.2 checks for cointegration among non-stationery variables for each country; this is done to ensure that the variables are not cointegrated before employing a VAR test.

Section 4.3 generates an unrestricted vector-autoregression model (VAR) using EViews in order to identify the significant relationship between interest rates, real oil prices, industrial production, and real stock returns.

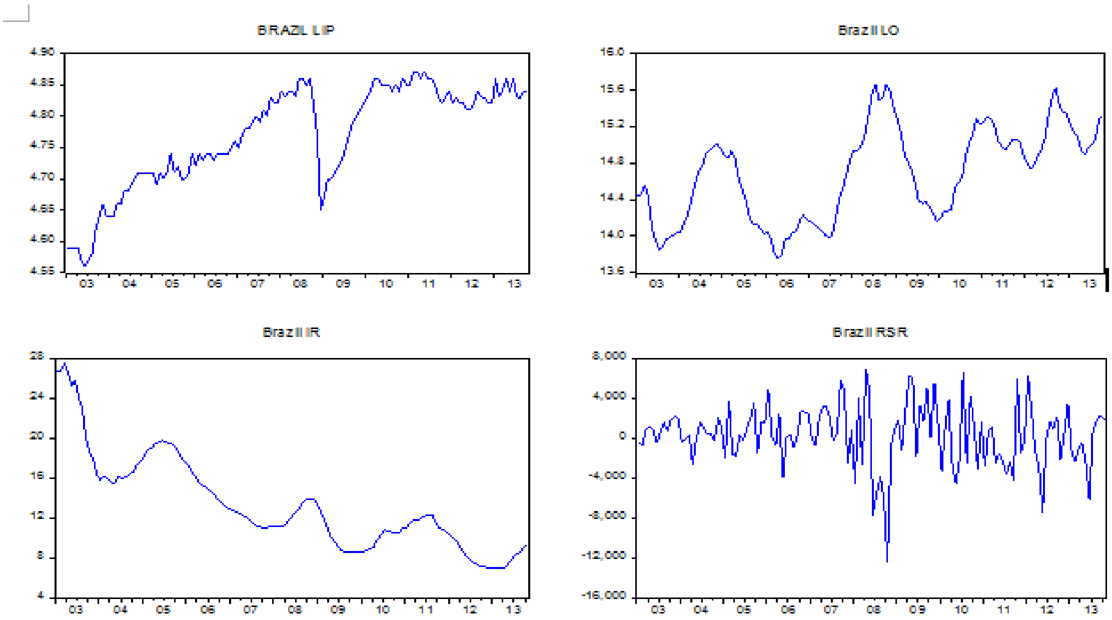
Section 4.4 implements the AR Roots Graph for Brazil, Germany and Norway to check whether the model is stable or not. Section 4.5 using EViews to implement the impulse response function in order to identify how the four endogenous variables, that is, Δir, Δlo, Δlip and rsr react to each other.

4.1. Unit Root Test

Before using the data it is crucial to identify if the series is stationery or non-stationery. The Unit root test was used along with the Augmented Dickey-Fuller test (ADF) and the Kwiatkowski–Phillips–Schmidt–Shin test (KPSS) in order to test for the unit root in level. In the case of data series being non-stationery the test for the unit in the first differences was calculated using EViews. Each country’s results are shown in the figures and tables below.

Figure 1 below shows in graphical form the summary of Brazil’s four economic variables. The graph suggests that all variables are non-stationery with the exception of rsr which is stationary. Hence, lip, lo, and ir are variables with data that is expected to have distribution changing over time.

Figure 1: Brazil’s time series graphs for all the economic variables



Source Eviews

Table 4 below gives a more detailed result for ADF and KPSS with regards to Brazil’s four economic variables. Note that not all KPSS results support the ADF test and vice versa. According to the ADF test in levels, only rsr reject the null of non-stationary. This means that only this rsr variable is integrated in order zero. Furthermore, both tests in first differences show that all variables are stationary.

Firstly, the unit root test in levels for Brazil’s lip results revealed that the t-statistic is |2.077| this is less than the t-test critical value at 1% level which is |3.481|. This means that the null hypothesis cannot be rejected. Hence, Brazil’s lip data series is non-stationery. As a result, this data series cannot be used in its present form. When using the test for unit in first difference however the t- statistics is |10.992| which is greater that the test critical values at 1% level of |3.482|. In this case, the null hypothesis can be rejected which is the 1st difference of Brazil’s lip and concludes that the data is stationery. Hence, the data was modified in order to find the first difference of Brazil’s lip.

Secondly, the unit root test for Brazil’s lo results revealed that the t-statistic is |2.969| which is less than the t-test critical value at 1% level of |3.482|. This means that the null hypothesis cannot be rejected. Hence, Brazil’s lo data series is non-stationery. As a result, this data series cannot be used in its present form. When using the test for unit in 1st

difference however the t- statistics is |5.467| which is greater that the test critical values at 1% level resulting in |3.482|. In this case, the null hypothesis can be rejected which is the 1st difference of Brazil's lo and concludes that data is stationery. Hence, data was modified to find the first difference of Brazil's lo.

Thirdly, the unit root test for Brazil's ir results revealed that the t-statistic is |3.042| which is less than the t-test critical value at 1% level of |3.482|. This means that the null hypothesis cannot be rejected. Hence, Brazil's ir data series is non-stationery. As a result, this data series cannot be used in its present form. When using the test for unit in 1st difference however the t- statistics is |3.758| which is greater that the test critical values at 1% level of |3.482|. In this case, the null hypothesis can be rejected which is the 1st difference of Brazil's ir and concludes that data is stationery. Hence, data was modified to find the first difference of Brazil's ir.

Lastly, the unit root test for Brazil's rsr results revealed that the t-statistic is |9.270| which is larger than the t-test critical value at 1% level of |3.481|. This means that the null hypothesis can be rejected. Hence, Brazil's rsr data series is stationery. As a result, this data series can be used in its present form.

Table 4: Brazil Unit Root test – ADF & KPSS Test

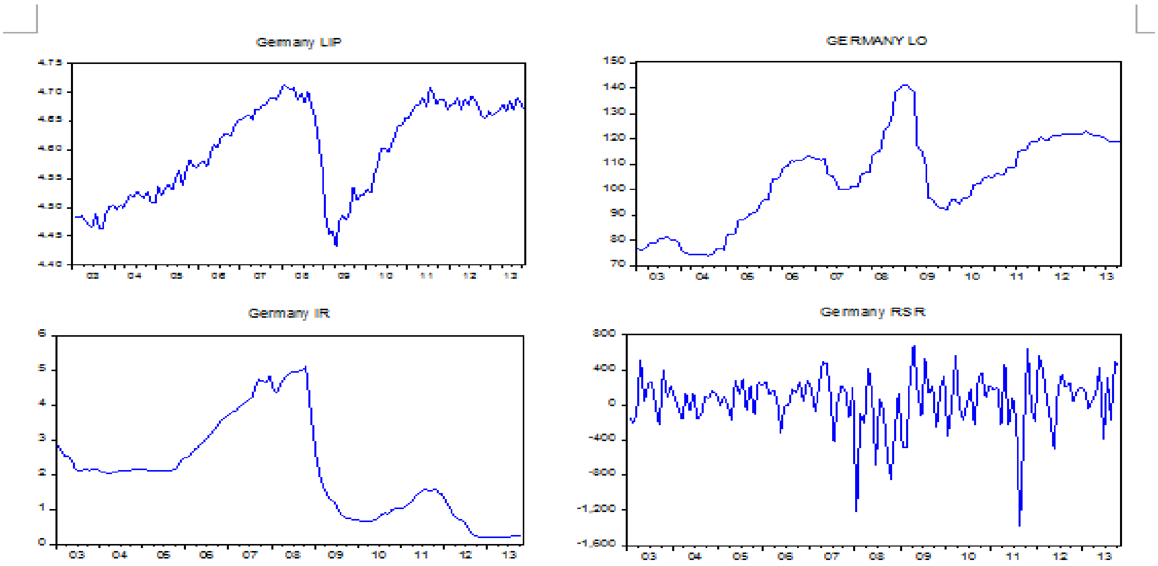
	Augmented Dickey-Fuller Test		**Kwiatkowski-Phillips-Schmidt-Shin**	
		In levels		
Brazil	t-statistic	critical value	test statistic	critical value
lip	-2.077	-3.481	1.106*	0.739
lo	-2.969	-3.482	0.618	0.739
lr	-3.042	-3.482	1.174*	0.739
rsr	-9.270*	-3.481	0.159	0.739
		In first differences		
Δlip	-10.992*	-3.482	0.095	0.739
Δlo	-5.467*	-3.482	0.041	0.739
Δlr	-3.758.*	-3.482	0.190	0.739
Δrsr	-10.230*	-3.483	0.093	0.739

(*) denotes rejection of the hypothesis at the 0.05 level
Source Eviews

Figure 2 below shows in graphical form the summary for Germany's four economic variables. The graphs suggest that all variables are non-stationery with the exception of rsr which is stationary. The results obtained are similar to Brazil's ADF and KPSS data analysis.

Hence, lip, lo, and ir are variables with data that is expected to have distribution changing over time.

Figure 2: Germany's time series graphs for all the economic variables



Source Eviews

Table 5 below gives a more detailed result for ADF and KPSS test with regards to Germany's four economic variables. Note that not all KPSS results support the ADF test and vice versa. According to the ADF test in levels, only rsr reject the null of non-stationary. This means that only this rsr variable is integrated in order zero. Furthermore, both tests in first differences show that all the variables except lo are stationary.

Firstly, the unit root test in levels for Germany's lip results revealed that the t-statistic is |2.329| which is less than the t-test critical value at 1% level of |3.482|. This means that the null hypothesis cannot be rejected. Hence, Germany's lip data series is non-stationery. As a result, this data series cannot be used in its present form. When using the test for unit in first differences however the t- statistics is |4.828| which is greater that the test critical values at 1% level of |3.483|. In this case, the null hypothesis can be rejected which is the first difference of Germany's lip and concludes that data is stationery.

Secondly, the unit root test for Germany's lo results revealed that the t-statistic is |2.662| which is less than the t-test critical value at 1% level of |3.482|. This means that the null hypothesis cannot be rejected. Hence, Germany's lo data series is non-stationery. As a result, this data series cannot be used in its present form. When using the test for unit in first differences however the t- statistics is |5.597| which is greater that the test critical values at

1% level of |3.484|. In this case, the null hypothesis can be rejected which is the 1st differences of Germany’s lo and concludes that data is stationery.

Thirdly, the unit root test for Germany ir results revealed that the t-statistic is |1.447| which is less than the t-test critical value at 1% level of |3.482|. This means that the null hypothesis cannot be rejected. Hence, Germany ir data series is non-stationery. As a result, this data series cannot be used in its present form. When using the test for unit in first differences however the t- statistics is |4.616| which is greater than the test critical values at 1% level of |3.482|. In this case, the null hypothesis can be rejected which is the first differences of Germany’s ir and concludes that data is stationery.

Lastly, the unit root test for Germany’s rsr results revealed that the t-statistic is |9.9530| which is larger than the t-test critical value at 1% level which is |3.481|. This means that the null hypothesis can be rejected. Hence, Germany rsr data series is stationery. As a result, this data series can be used in its present form. When using the test for unit in first differences however the t- statistics is |10.016| which is greater that the test critical values at 1% level |3.482|. This supports the ADF test in levels.

Table 5 Germany’s Unit Root test – ADF & KPSS Test

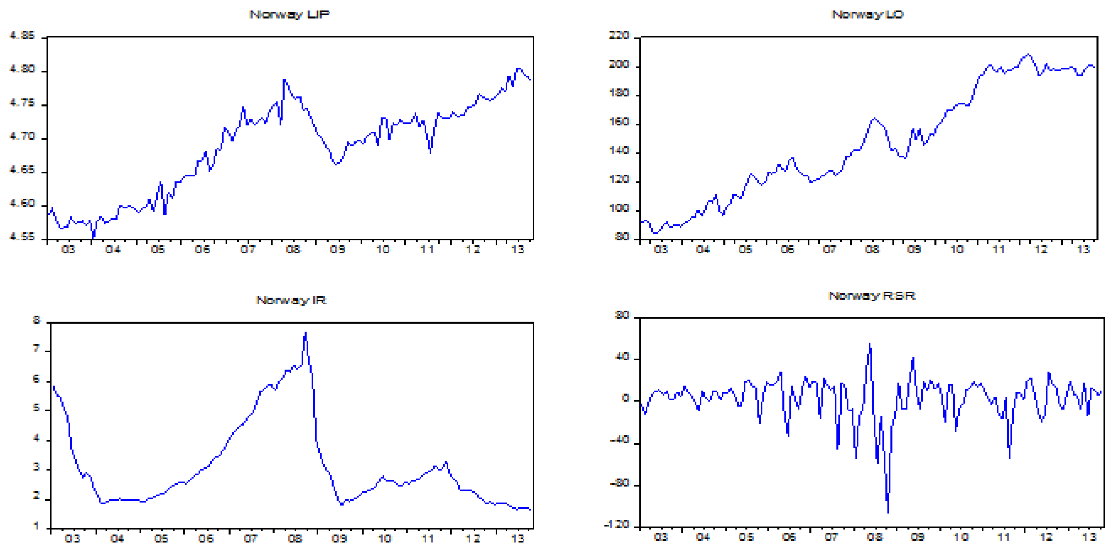
	Augmented Dickey-Fuller Test		**Kwiatkowski-Phillips-Schmidt-Shin**	
		In levels		
Germany	t-statistic	critical value	test statistic	critical value
lip	-2.329	-3.482	0.628	0.739
lo	-1.576	-3.484	0.665	0.739
lr	-1.447	-3.482	0.574	0.739
rsr	-9.953*	-3.481	0.089	0.739
		In 1st differences		
Δlip	-4.282*	-3.483	0.064	0.739
Δlo	-5.597*	-3.484	0.117	0.739
Δlr	-4.616*	-3.482	0.121	0.739
Δrsr	-10.016*	-3.482	0.049	0.739

(*) denotes rejection of the hypothesis at the 0.05 level
Source Eviews

Figure 3 below shows in graphical form the summary for Norway’s four economic variables. The graph shows that all variables are non-stationery with the exception of rsr which is stationary. The results obtained are similar to Brazil’s and Germany’s ADF and

KPSS test data analysis. Hence, lip, lo, and ir are variables with data that is expected to have distribution changing over time.

Figure 3: Norway's time series graphs for all the economic variables



Source Eviews

Table 6 below gives a more detailed result for ADF and KPSS with regards to Norways's four economic variables. Note that not all KPSS results support the ADF test and vice versa. According to the ADF test in levels, only rsr reject the null of non-stationary. This means that only this rsr variable is integrated in order zero. Furthermore, both tests in first differences show that all variables are stationary.

Firstly, the unit root test in levels for Norways's lip results revealed that the t-statistic is |0.820| this is less than the t-test critical value at 1% level of |3.482|. This means that the null hypothesis cannot be rejected. Hence, Norways's lip data series is non-stationery. As a result, this data series cannot be used in its present form. When using the test for unit in first difference however the t- statistics is |16.455| which is greater that the test critical values at 1% level of |3.482|. In this case, the null hypothesis can be rejected which is the first differences of Germany's lip and concludes that the data is stationery.

Secondly, the unit root test for Norway's lo results revealed that the t-statistic is |0.697| which is less than the t-test critical value at 1% level of |3.482|. This means that the null hypothesis cannot be rejected. Hence, Norway's lo data series is non-stationery. As a result, this data series cannot be used in its present form. When using the test for unit in first differences however the t- statistics is |10.530| which is greater that the test critical values at 1% level of |3.482|. In this case, the null hypothesis can be rejected which is the first differences of Norway's lo and concludes that data is stationery.

Thirdly, the unit root test for Norway's ir results revealed that the t-statistic is |2.319| which is less than the t-test critical value at 1% level of |3.483|. This means that the null hypothesis cannot be rejected. Hence, Norway's ir data series is non-stationery. As a result, this data series cannot be used in its present form. When using the test for unit in first difference however the t- statistics is |3.669| which is greater that the test critical values at 1% level of |3.484|. In this case, the null hypothesis can be rejected which is the first differences of Norway's ir and concludes that data is stationery.

Lastly, the unit root test for Norway's rsr results revealed that the t-statistic is |7.882| which is larger than the t-test critical value at 1% level of |3.481|. This means that the null hypothesis can be rejected. Hence, Norway's rsr data series is stationery. As a result, this data series can be used in its present form.

Table 6: Norway's Unit Root test – ADF & KPSS Test

	Augmented Dickey-Fuller Test		**Kwiatkowski-Phillips-Schmidt-Shin**	
		In levels		
Norway	t-statistic	critical value	test statistic	critical value
lip	-0.820	-3.482	1.115*	0.739
lo	-0.697	-3.481	1.347*	0.739
lr	-2.319	-3.483	0.223	0.739
rsr	-7.882*	-3.481	0.097	0.739
		In 1st differences		
Δlip	-16.455*	-3.482	0.075	0.739
Δlo	-10.530*	-3.482	0.056	0.739
Δlr	-3.669*	-3.484	0.112	0.739
Δrsr	-12.555*	-3.482	0.258	0.739

(*) denotes rejection of the hypothesis at the 0.05 level
Source Eviews

4.2 Cointegration

Furthermore, the cointegration test was conducted for non-stationary variables to ensure that they are not cointegrated before employing a VAR test. In case of cointegration a VEC model will be used. As showed by the ADF and KPSS test, only some variables for each country need to be tested for cointegration.

Table 7 below shows the result of Brazil's cointegration test among lip, lo and ir. The lag selection criterion is based on Akaike Information Criterion (AIC). Hence a lag of five was used for Brazil. The results reveal that both trace test and maximum eigenvalue test indicate cointegration at 5% level. Due to the fact that the three variables are cointegrated then the VAR model cannot be applied but the Vector Error Regression Model can be applied. Therefore, the VEC model can be conducted for all four variables which are Δlip, Δlo, Δlr and rsr.

Table 7: Brazil's Cointegration test for lip, lo and ir using Johansen test

Brazil	**Unrestricted Cointegration Rank Test (Trace)**			
Hypothesis	Eigenvalue	Trace	0.05 Critical Value	Prob.**
None*	0.145379	43.32245	29.79707	0.0008
At most 1*	0.120066	23.84247	15.49471	0.0022
	Unrestricted Cointegration Rank Test (Maximum Eigenvalue)			
Hypothesis	Eigenvalue	λ - Max	0.05 Critical Value	Prob.**
None*	0.145379	19.47998	21.13162	0.0838
At most 1	0.120066	15.86069	14.26460	0.0277

* denotes rejection of the hypothesis at the 0.05 level
*Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Max-eigenvalue test indicates 4 cointegrating eqn(s) at the 0.05 level
Source Eviews

Table 8 below shows the result of Germany's cointegration test among lip, lo and ir. The lag selection criterion is based as suggested by Akaike Information Criterion (AIC). Hence a lag of five was used. The results reveal that all three variables in both trace test and maximum eigenvalue test are not cointegrated in 5% level. Meaning that in the longer-run the variables do not move in the same direction. Hence, with this results obtained the VAR model can be conducted for all four variables which are Δlip, Δlo and Δlr and rsr.

Table 8 : Germany Cointegration test for lip, lo and ir using Johansen test

Germany	Unrestricted Cointegration Rank Test (Trace)			
Hypothesis	Eigenvalue	Trace	0.05 Critical Value	Prob.**
None	0.089527	17.66070	29.79707	0.5912
At most 1	0.047998	6.218238	15.49471	0.6697
	Unrestricted Cointegration Rank Test (Maximum Eigenvalue)			
Hypothesis	Eigenvalue	λ - Max	0.05 Critical Value	Prob.**
None	0.106258	13.92989	21.13162	0.3708
At most 1	0.082809	10.71846	14.26460	0.1689

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-value
Max-eigenvalue test indicates no cointegration at the 0.05 level
Source Eviews

Table 9 below shows the result of Norways's cointegration test among lip, lo and ir. The lag selection criterion is based as suggested by Akaike Information Criterion (AIC). Hence a lag of three was used. The results reveal that all three variables in both trace test and maximum eigenvalue test are not cointegrated in 5% level. Meaning that in the long-run the variables do not move in the same direction. Hence, the VAR model can be applied including to Δlip, Δlo and Δlr, since variables are not correlated in the longer run.

Table 9: Norway Cointegration test for lip, lo and lr using Johansen test

Norway	Unrestricted Cointegration Rank Test (Trace)			
Hypothesis	Eigenvalue	Trace	0.05 Critical Value	Prob.**
None	0.086515	17.61540	29.79707	0.5946
At most 1	0.050019	6.575834	15.49471	0.6274
	Unrestricted Cointegration Rank Test (Maximum Eigenvalue)			
Hypothesis	Eigenvalue	λ - Max	0.05 Critical Value	Prob.**
None	0.086515	11.03956	21.13162	0.6434
At most 1	0.050019	6.260205	14.26460	0.5801

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-value
Max-eigenvalue test indicates no cointegration at the 0.05 level
Source Eviews

4.3 Vector Autoregression Model (VAR)

An unrestricted vector-autoregression is generated to identify the significant relationship between interest rates, real oil prices, industrial production, and real stock returns. Table 6 presents the matrix generated from VAR. In VAR, ordering of the endogenous variables and the right length of lag is very essential.

The ordering of the variables are set in accordance with Sadorsky’s (1999) paper whereby the interest rates is placed in the first followed by real oil prices, industrial production, and real stock returns. As a matter of fact, Sadorsky (1999) paper argues that this way of ordering assumes contemporaneous disturbances. As a result, it does not have any influence over the monetary policy shocks. Ferderer (1996) used the same ordering whereby he argues that this ordering show the influence interest rates has on real oil prices.

The equation used in order to determine VAR for Δlr, Δlo, Δlip, and rsr is as follows:

$$\Delta lr_t = \beta_{1,1}\Delta lr_{t-1} + \cdots + \beta_{1,4}\Delta lr_{t-4} + \beta_{1,5}\Delta lo_{t-1} + \cdots + \beta_{1,8}\,{}_{\Delta}\Delta lo_{t-4} + \beta_{1,9}\Delta lip_{t-1} + \cdots + \beta_{1,12}\Delta lip_{t-4} + \beta_{1,13} rsr_{t-1} + \cdots + \beta_{1,16} rsr_{t-4} + \beta_{1,17} \quad (14)$$

$$\Delta lo_t = \beta_{2,1}\Delta lr_{t-1} + \cdots + \beta_{2,4}\Delta lr_{t-4} + \beta_{2,5}\Delta lo_{t-1} + \cdots + \beta_{2,8}\Delta lo_{t-4} + \beta_{2,9}\Delta lip_{t-1} + \cdots + \beta_{2,12}\Delta lip_{t-4} + \beta_{2,13} rsr_{t-1} + \cdots + \beta_{2,16} rsr_{t-4} + \beta_{2,17} \quad (15)$$

$$\Delta lip_t = \beta_{3,1}\Delta lr_{t-1} + \cdots + \beta_{3,4}\Delta lr_{t-4} + \beta_{3,5}\Delta lo_{t-1} + \cdots + \beta_{3,8}\Delta lo_{t-4} + \beta_{3,9}\Delta lip_{t-1} + \cdots + \beta_{3,12}\Delta lip_{t-4} + \beta_{3,13} rsr_{t-1} + \cdots + \beta_{3,16} rsr_{t-4} + \beta_{3,17} \quad (16)$$

$$rsr_t = \beta_{4,1}\Delta lr_{t-1} + \cdots + \beta_{4,4}\Delta lr_{t-4} + \beta_{4,5}\Delta lo_{t-1} + \cdots + \beta_{4,8}\Delta lo_{t-4} + \beta_{4,9}\Delta lip_{t-1} + \cdots + \beta_{4,12}\Delta lip_{t-4} + \beta_{4,13} rsr_{t-1} + \cdots + \beta_{4,16} rsr_{t-4} + \beta_{4,17} \quad (17)$$

Table 10 below shows the results for Brazil residual variance-covariance matrix from a restricted VAR (2003:01- 2013:10). It clearly indicates a negative correlation between changes in interest rates and stock returns. It also shows a negative correlation between changes in oil prices and stock returns. Moreover, there is a negative correlation between stock returns and interest rates.

Table 10: Brazil Variance-Covariance Matrix

	Δlr	Δlo	Δlip	rsr
Δlr	0.102346	0.003215	-0.000267	-155.9946
Δlo	0.003215	0.007420	-5.56E-05	-23.04897
Δlip	-0.000267	-5.56E-05	0.000245	-1.686535
rsr	-155.9946	-23.04897	-1.686535	9392459.

Source Eviews

Table 11 below shows the results for Germany residual variance-covariance matrix from unrestricted VAR (2003:01- 2013:10). The results clearly indicate a negative correlation between changes in interest rates and stock returns and vice versa are also the case. It also shows a negative relationship between changes in interest rates and oil prices. Furthermore, there is a negative correlation between stock returns and changes in interest rates.

Table 11: Germany Variance-Covariance Matrix

	Δlr	Δlo	Δlip	rsr
Δlr	0.01324	-0.00394	0.00042	-0.55974
Δlo	-0.00394	4.91146	0.00408	-109.15717
Δlip	0.00042	0.00408	0.00018	-0.01053
rsr	-0.55974	-109.15717	-0.01054	101294.163

Source Eviews

Table 12 below shows the results for Norway residual variance-covariance matrix from unrestricted VAR (2003:01- 2013:10). The results clearly indicate a negative correlation between changes in interest rates and stock returns. It also shows a negative correlation between stock returns and changes in interest rates.

Table 12: Norway Variance -Covariance Matrix

	Δlr	Δlo	Δlip	rsr
Δlr	0.068678	0.005270	0.000363	-1.434790
Δlo	0.005270	16.01265	0.000817	-6.842143
Δlip	0.000363	0.000817	0.000213	0.051145
rsr	-1.434790	-6.842143	0.051145	348.9919

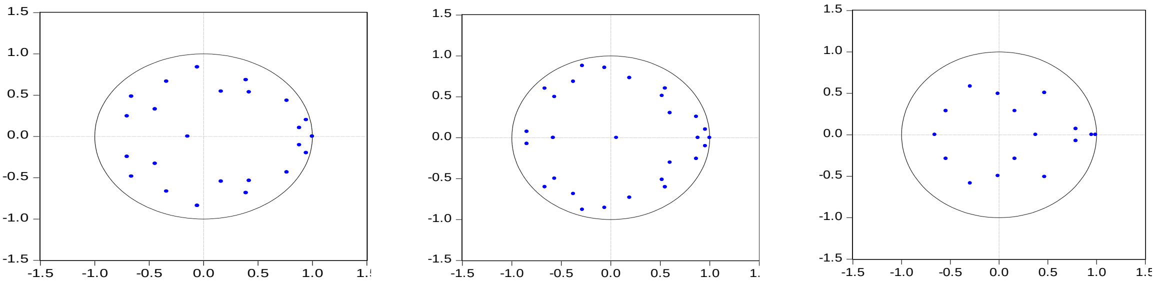
Source Eviews

The results of the covariance-matrix calculated for Brazil, Germany and Norway are in accordance with Sadrosky (1999) findings. Whereby the results for all the three countries not only show a negative correlation between changes in oil prices and stock returns but also show negative correlation between stock returns and interest rates.

4.4 Inverse Roots of AR Characteristic Polynomial

In order to test for stability the AR Roots Graph was used. Figure 4 below shows the AR Roots Graph for Brazil, Germany and Norway. From the graph it can be depicted that all roots have absolute value less than one. This is shown by the fact that all roots lie inside the unit circle. Therefore, this suggests that our model is stable.

Figure 4: Brazil, Germany and Norway, respectively AR Roots Graph



Source Eviews

4.5 Impulse Response Function

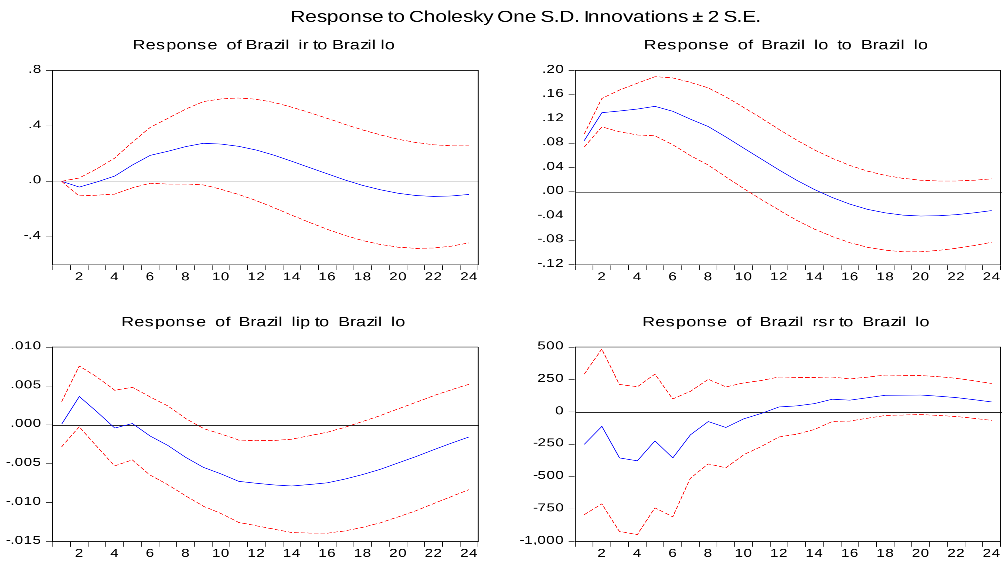
The impulse response function was run in EViews in order to identify how the four endogenous variables react to each other, that is, Δir, Δlo, Δlip and rsr. Note that the ordering of the variables followed Sardosky's suggestions while looking at 24 months into the future. One shock was given to each residual and the results obtained for each country is as follows.

4.5.1 Results for Brazil Impulse Response Function

From Figure 5, which demonstrates a response to Brazil's interest rates shocks, refer to the appendix, illustrates that the interest rate shock has a negative effect on stock returns. This show the importance of interest rate shocks on the stock market. These results are in accordance with Sadorsky's (1999) findings. Whereby he has three arguments as to why the changes in interest rates influence the stock market. Firstly, changes in interest rates determine the amount of equity investors are willing to pay which means that the higher the price the higher the amount investors have to pay. As a result, this will affect the stock market activity. Secondly, changes in interest rates influence the price of financial assets. Lastly, since certain stocks are purchased on margin, increases in interest rate will cause a rise in cost of margin; hence lowering the stock returns.

Figure 6 below, which show a response to Brazil's real oil prices shocks, refer to the appendix, illustrates that an oil price shock initially has a negative effect on real stock returns. This result is in accordance with Sadorsky's (1999) findings; whereby he argues that changes in oil price affect industrial production. As a result, this have a negative effect on profits of a company since oil is considered to be a cost of production. Furthermore, from the graph it can be depicted that oil price shocks has a negative effect on industrial production. This result is in accordance with Uri (1996) findings who argue that an increase in oil price will decrease industrial production since increases in oil prices will increase the cost of production. As a matter of fact, companies that utilize oil in production are affected by oil price shocks since their production will decline. Note that the oil price shocks at the end of the period have an insignificant influence on interest rates.

Figure 6: Response to Brazil real oil price shocks



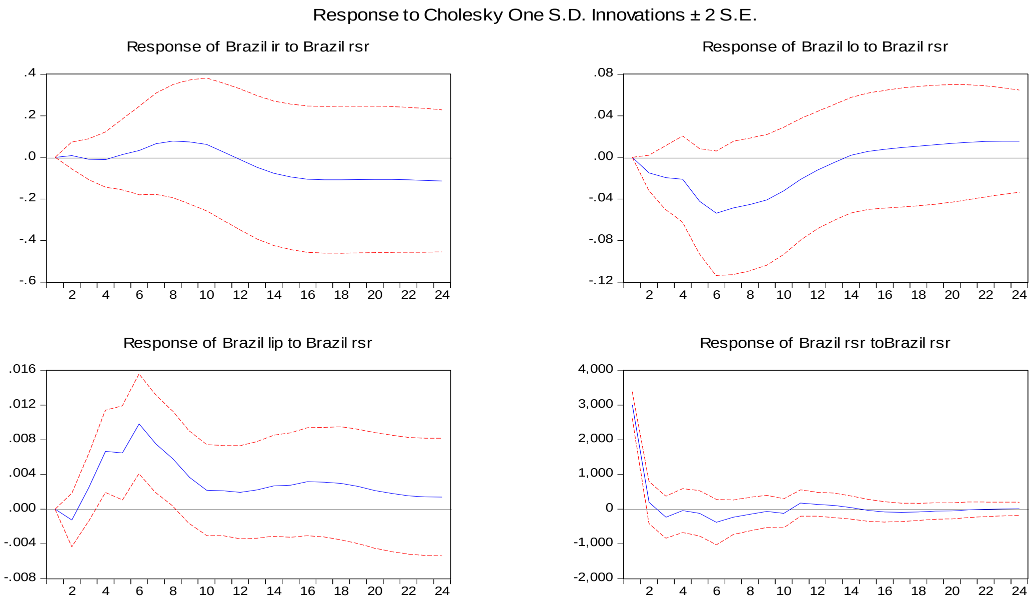
Source Eviews

Figure 7 which show a response to Brazil's industrial production shocks, refer to the appendix, illustrates that an industrial production shock initially has a negative effect on interest rates. Furthermore, stock returns have a negative impact on the first five months.

After that period however they show no significant effect. Industrial production shock generates a negative impact on the oil price.

Figure 8 below which show a response to Brazil's real stock return shocks, refer to the appendix, illustrates that a stock return shock has a negative effect on interest rates at the end of the period. Furthermore, stock return shocks have a positive response in industrial production. This is in accordance with Sadorsky (1999) results; whereby Sadorsky (1999) makes reference to Lee (1992) findings in that they state that the stock market is the primary indicator of real economic activity.

Figure 8: Response to Brazil real stock return shocks



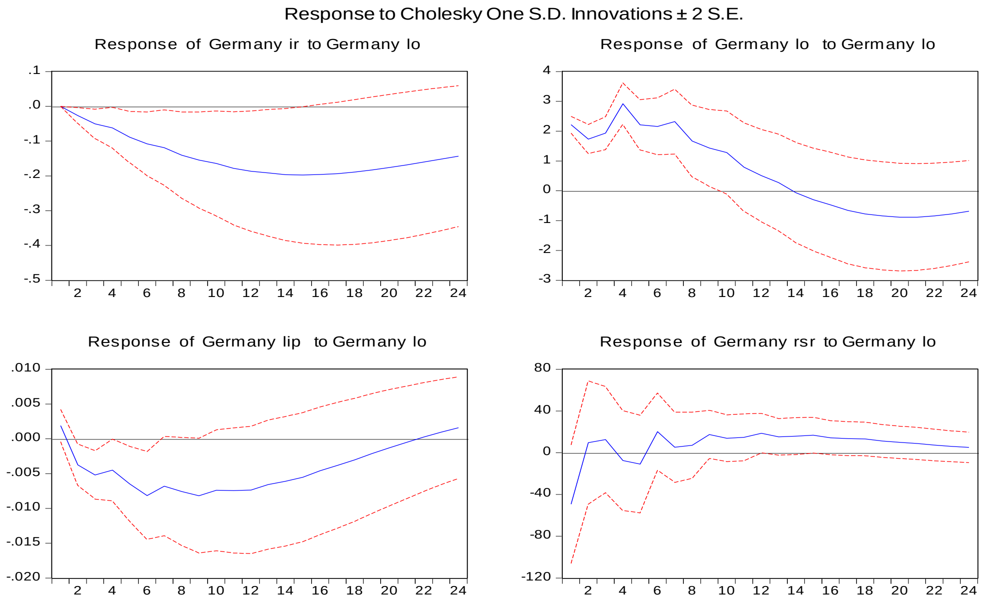
Source Eviews

4.5.2 Results for Germany Impulse Response Function

Figure 9 which shows a response to Germany's interest rate shocks, refer to the appendix, suggests that an interest rate shock has a positive effect on stock returns. This shows the importance of interest rate shocks on the stock market. Figure 9, also illustrates that interest rate shocks for Germany which is an oil importing country has a positive impact on oil prices and in the last three months it has a slightly negative effect.

Figure 10 below, which show a response to Germany's real oil prices shocks, refer to the appendix, illustrates that an oil price shock causes an instant response of real stock returns. These results are in accordance with Jungwook Park and Ronald Ratti (2008) findings. From figure 10, it can also be stated that oil price shocks cause a positive response to interest rates especially in the last quarter of the period. This finding is also in accordance with Papatrou's (2001) research whereby he argues that oil price movement plays a crucial role in identifying real stock returns. Furthermore, oil price shocks show a negative impact on industrial production. This result is in accordance with Papapetrou, E. (2001) findings who argues that increasing the costs of production result in a decrease in output and a decrease in employment level. As a result, he concluded that oil price shocks have an instant negative effect on industrial production.

Figure 10: Response to Germany real oil price shocks

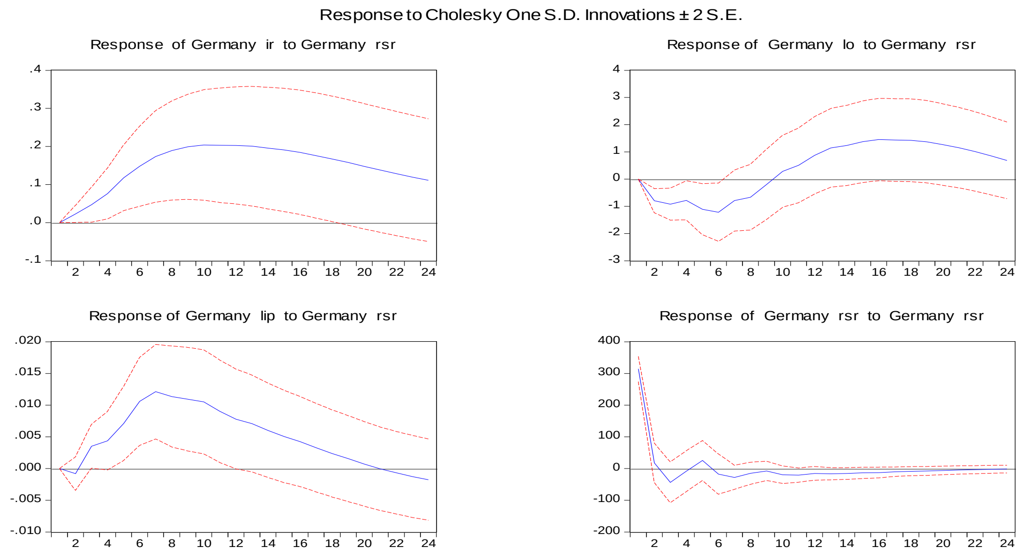


Source Eviews

Figure 11 which show a response to Germany's industrial production shocks, refer to the appendix, illustrates that an industrial production shocks initially has a positive effect on interest rates which reflects Germany's strong economy. Furthermore, industrial production shock has a slightly negative impact on stock returns. After that period however they show no significant effect. Industrial production shock generates a positive impact on the oil price. These results are in accordance with Leonard's (2011) results. Whereby his findings reveal that industrial production in China plays a crucial role when it comes to influencing global movements in oil market.

Figure 12 which show a response to Germany's real stock return shocks, refer to the appendix, illustrates that a stock return shock has a positive effect on interest rates. Furthermore, stock return shocks have a positive response in industrial production. This is in accordance with Sadorsky (1999) results. Whereby Sadorsky (1999) makes reference to Lee (1992) findings in that they state that the stock market is the primary indicator of real economic.

Figure 12: Response to Germany real stock return shocks



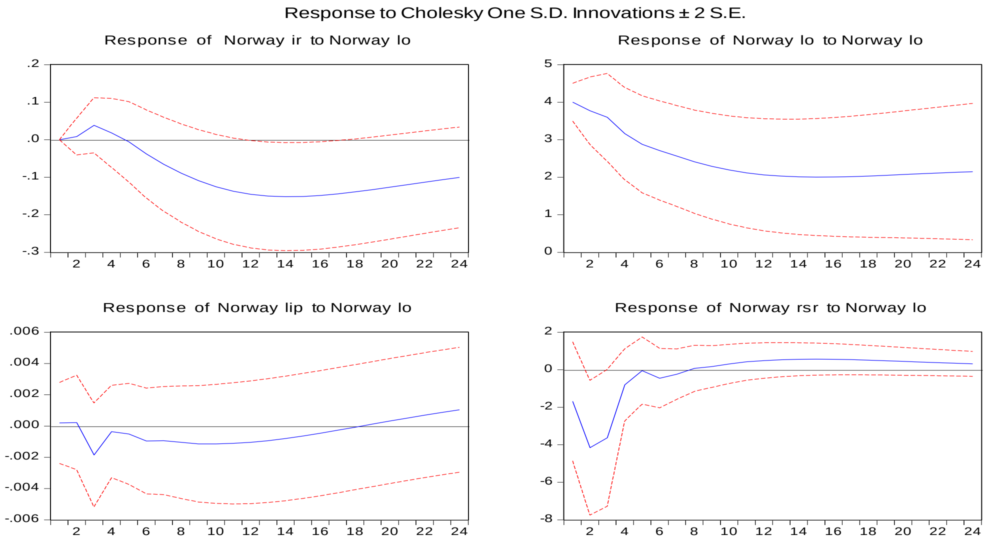
Source Eviews

4.5.3 Results for Norway Impulse Response Function

Figure 13 which shows a response to Norway's interest rate shocks, refer to the appendix, indicates that an interest rate shock has a negative effect on stock returns. These results are in accordance with Sadorsky's (1999) findings. From Figure 13 it can also be depicted that interest rate shocks for Norway which is an oil exporting country has a negative impact on oil prices. In case of industrial production response is negative for the last 12 months.

Figure 14 below, which show a response to Norway's real oil prices shocks, refer to the appendix, illustrates that oil price shock causes a negative response on interest rates and a positive response on real stock return at the end of the period. These results are in accordance with Park and Ratti (2008) findings whereby they argue that increases in oil price benefits companies in Norway since Norway is known to be net exporter of oil. Gjerde and Saettem (1999) results also reveal that there is a positive association between oil prices and OSE stock prices. Furthermore, oil price shocks show a negative impact on industrial production and have a slight positive impact in the last months of the period. This result is in accordance with Papapetrou, E. (2001) findings who argues that increasing the costs of production result in a decrease in output and a decrease in employment level.

Figure 14: Response to Norway real oil price shocks

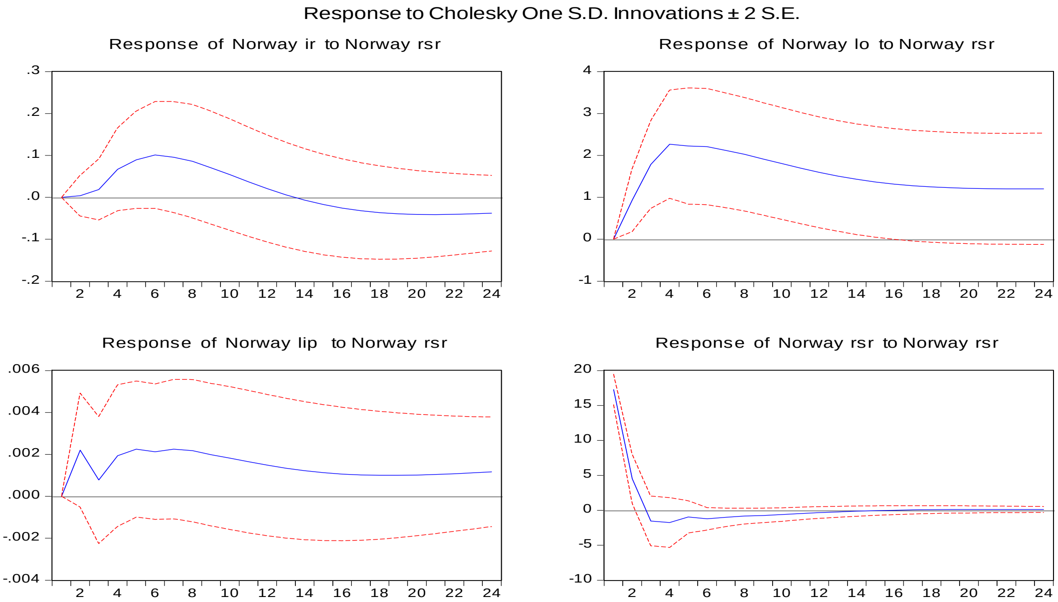


Source Eviews

Figure 15 which show a response to Norway's industrial production shocks, refer to the appendix, illustrates that an industrial production shocks initially has a positive effect on interest rates which reflects Norway's strong economy. Furthermore, industrial production shock has a slightly negative impact on stock returns. After that period however they show no significant effect. Industrial production shock generates a positive impact on the oil price. These results are similar to the results obtained for Germany. Leonard's (2011) results support this findings since he reveal that industrial production in China plays a crucial role when it comes to influencing global movements in oil market.

Figure 16 below which show a response to Norway's real stock return shocks, refer to the appendix, indicates that a stock return shock has a positive effect on interest rates with a negative effect at the end of the period. Furthermore, stock return shocks have a positive response in industrial production. The results obtained are the same for Germany. This is in accordance with Sadorsky (1999) results. Whereby Sadorsky (1999) makes reference to Lee (1992) findings in that they point out that the stock market is the primary indicator of real economic.

Figure 16: Response to Norway real stock returns shocks



Source Eviews

In general, the impulse response function in particular the results for real oil price shocks reveal similar results. A difference is shown for the effect on interest rates only for Brazil. Where by the response to Brazil's real oil price shocks illustrates a positive effect on interest rates while for Germany and Norway it has a negative effect. These results reveal the strong economy for Germany and Norway.

Furthermore, the response to Brazil's, Germany's and Norway's real oil price shocks illustrates a negative effect on industrial production. These results once more prove Sadorsky (1999) findings whereby he argues that the stock market is the primary indicator of real economy.

On the other hand, the response to Brazil's and Norway's real oil price shocks illustrates a positive effect on real oil price itself which can be justified due to the fact that both are oil exporting countries. As a matter of fact, the results obtained were in accordance with Sadorsky (1999) whereby he concluded that oil price shocks initially have a negative impact on stock returns which were the results obtained for Brazil and Norway. These results were expected since both are oil exporting countries.

4.6 Variance Decomposition

A summary of the results of the variance decompositions for Brazil, Germany and Norway are presented in the tables below. The test uses Cholesky's Decomposition with the following ordering, changes in interest rates, changes in real oil prices, changes in industrial production, and real stock returns. The acronyms $\varepsilon^{ir}, \varepsilon^{lo}, \varepsilon^{lip},$ and ε^{rsr} represent the shocks to errors. Note that the variance decompositions follow orders of 24 months and uses Monte Carlo standard errors of 1000 repetitions as used not only by Sadorsky (1999) but also used by McCue and Kling (1994).

4.6.1 Results for Brazil Variance Decomposition

Table 14 below shows the results for Brazil's 24 month period variance decomposition for the whole period from January 2003 to October 2013. The results reveal that changes for interest rates are dominated by its own shocks accounting for more than half, which is 53%. Similar results were obtained for changes in real oil prices; it clearly shows that oil price shocks are dominating the variance decomposition. Hence, the oil price shocks accounts for 87% whereas other shocks are less than 10%. This argues that Brazil's economic variables have little impact on oil prices, whereas oil price movements have a great impact on Brazil's economic variables.

The variance decomposition for variable changes in industrial production is determined by oil price movement shocks which accounts for 45%, followed by interest rate shocks which account for 26%. Furthermore, after 24 months, real stock returns shocks account for 77% followed by oil price shocks which account for 11% of the forecast error variance. Interest rates and oil price shocks do not have a great impact on real stock returns.

Table 13: Brazil's 24 month period variance decomposition

	ε^{r}	ε^{o}	ε^{ip}	ε^{rsr}
Δlr	53.62617	23.22215	13.72345	9.428228
Δlo	3.448543	87.48338	2.566837	6.501242
Δlip	26.86898	45.88355	14.33812	12.90936
rsr	4.262172	11.54196	6.281836	77.91404

Source Eviews

4.6.2 Results for Germany Variance Decomposition

Table 15 below shows the results for Germany's 24 month period variance decomposition for the whole period January 2003 to October 2013. The results show that changes for interest rates are dominated by its own shocks accounting for 34%. It is also important to note that changes in interest rates are also affected by real stock return and changes in oil prices accounting for 30% and 29%, respectively. On the other hand, changes in real oil prices shows that industrial production shocks are dominating the variance decomposition accounting for 31% whereas oil price shocks account for 29% and interest rates accounting for 23%. This argues that Germany's economic variables have an impact on oil prices.

The variance decomposition for variable changes in industrial production is determined by its own shocks accounting for 37%, followed by real stock return shocks which account for 25%.

Furthermore, after 24 months, real stock returns shocks account for 86% of the forecast error variance. The three other shocks do not show an impact since they only account for less than 10%.

Table 14: Germany's 24 month period variance decomposition

	ε^r	ε^o	ε^{ip}	ε^{rsr}
Δlr	34.37972	29.35040	5.634219	30.63566
	(17.0014)	(17.5716)	(7.67655)	(13.8229)
Δlo	23.94837	29.40569	31.30681	15.33913
	(11.9127)	(11.4861)	(12.4002)	(9.76044)
Δlip	19.75126	17.18319	37.63434	25.43122
	(10.6820)	(12.9424)	(14.2019)	(11.9873)
rsr	7.486425	5.025225	1.389948	86.09840
	(4.94776)	(4.08071)	(2.72660)	(6.58528)

Source Eviews

4.6.3 Results for Norway Variance Decomposition

Table 16 below shows the results for Norway's 24 month period variance decomposition for the whole period from January 2003 to October 2013. The results show that changes for interest rates are dominated by its own shocks accounting for more than half, which is 52%. Similar results were obtained for changes in real oil prices; it clearly shows that oil price shocks are dominating the variance decomposition. Hence, the oil price shocks accounts for 55% whereas stock return is 22% while the other shocks have the minority effect on the variables. This argues that Norway's oil price movements have a great impact on its economic variables.

The variance decomposition for variable changes in industrial production is determined by oil price movement shocks which accounts for 89%. This result is consistent with Lee (1992) who argued that movement in changes in industrial production explains 98% of the variance decompositions. Furthermore, after 24 months, real stock returns shocks account for 71% whereby the other variables have little impact.

Table 15: Norway's 24 month period variance decomposition

	ε^{r}	ε^{o}	ε^{ip}	ε^{rsr}
Δlr	52.12790	15.20684	29.46551	3.199747
	(16.8622)	(10.6305)	(12.5477)	(5.43997)
Δlo	12.23129	55.83937	9.788516	22.14082
	(12.4556)	(16.1347)	(12.4242)	(11.8574)
Δlip	6.519062	1.093549	88.73572	3.651667
	(7.95645)	(5.24027)	(10.8511)	(6.26750)
rsr	12.95575	8.045127	7.810636	71.18849
	(5.69888)	(4.98312)	(4.49292)	(8.16220)

Source Eviews

Overall, the results for Brazil's and Norway's 24 month period variance decomposition for the whole period from January 2003 to October 2013 illustrates that Brazil's and Norway's economic variables have little impact on oil prices, whereas oil price movements have a great impact on their economic variables. These results are similar for both countries since they are considered oil exporting countries. While the results for Germany illustrate that the four economic variables discussed earlier have little impact on oil prices.

5. Conclusion and Discussion

This dissertation examines the Brazilian (BOVESPA), German (DAX 30), and Norwegian (OSE) stock market behaviour in relation to oil price shocks. A total of 130 observations were used whereby monthly data for a period of ten years with samples from January 2003 to October 2013 was considered. All data was gathered using DataStream. The variables utilized are the natural logarithms of industrial production (lip) which measure output of production, real oil prices (lo), T-bill rate (ir) and real stock returns (rsr) for Brazil, Germany and Norway. Whereby Brazil and Norway are oil exporting countries and Germany is an oil importing country.

The effect of oil price shocks on stock return is analysed by specifically using multivariate vector autoregressive model (VAR). Before applying the VAR model however, a cointegration test was conducted for non-stationary variables which in this case are lip,lo and ir for Brazil, Germany and Norway. The cointegration test result shows that the variables for all the three countries except for Brazil, do not have long run relationship among the variables lip, lo and lr, which implies that the VAR model can be applied for all four economic variables which are Δlip, Δlo, Δlr and rsr.

In the case for Brazil however, the cointegration test among lip, lo and ir results reveal that the three variables are cointegrated. Hence, the Vector Error Correction Model is conducted for Brazil's four economic variables. Note that detailed explanation of VAR is given by performing an impulse responses functions and variance decomposition analysis.

Therefore, the impulse response function results reveal that Brazil's interest rates shocks, has a significant negative effect on stock returns. This show the importance of interest rate shocks on the stock market. These results are in accordance with Sadorsky's (1999) findings. Furthermore, Brazil's real oil price shocks reveal that an oil price shock initially has a significant negative effect on stock returns. These results are in accordance with Sadorsky's (1999) findings; whereby he argues that changes in oil price affect industrial production.

Furthermore, Brazil's stock return shocks have a positive response in industrial production. This is in accordance with Sadorsky (1999) results; whereby Sadorsky (1999) makes reference to Lee (1992) findings in that they state that the stock market is the primary indicator of real economic activity.

The impulse response function results reveal that Germany's interest rate shocks have a positive effect on stock returns. This shows the importance of interest rate shocks on the stock market. Germany's real oil prices shocks indicate that an oil price shock causes an instant response of real stock returns. These results are in accordance with Jungwook Park and Ronald Ratti (2008) findings. Germany's industrial production shocks indicate that an industrial production shocks initially has a positive effect on interest rates which reflects Germany's strong economy. Germany's stock return shocks, indicates that a stock return shock has a positive effect on interest rates.

The impulse response function results reveal that Norway's interest rate shock has a negative effect on stock returns. These results are in accordance with Sadorsky's (1999) findings. Norway's oil prices shocks indicate that it causes a negative response on interest rates and a positive response on real stock return at the end of the period. These results are in accordance with Park and Ratti (2008) findings whereby they argue that increases in oil price benefits companies in Norway since Norway is known to be net exporter of oil.

In conclusion, results obtained for Brazil and Norway are similar to Sadorsky's (1999) results in that oil price shocks initially have a negative impact on stock returns. These results were expected as it is justifiable since both countries are oil exporting. Furthermore, an important result obtained was that the economic variables are influenced by movements in oil prices; vice-versa however is not the case. Therefore, oil price shocks have a significant impact on the stock market for the three countries analysed, i.e Brazil, Germany and Norway.

Future research can be conducted on each country and its industrial sector to identify whether the effects of oil price shocks vary from oil importing and oil exporting countries. Furthermore, it is crucial to note that a weakness of my research paper is that it is limited to data analysis for ten years. Therefore, future research papers can consider more years for analysis while a forecast can also be considered.

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Results Appendix

The appendix records three sections. Section I, shows the results for the Lag selection criteria for Brazil, Germany and Norway which takes record of the Lag selection by the Akaike Information Criterion (AIC).

Section II, shows the results of the Vector Autoregression Model (VAR) and Vecor Error Correction Model (VECM) for Brazil, Germany and Norway.

The last section shows the impulse responses function for Brazil, Germany and Norway's variables i.e. change in interest rate (Δir), changes in real oil prices (Δlo), changes in industrial production (Δlip) and real stock return (rsr) and how they react to each other.

Section I

Section I is comprised of Figure 16, 17 and 18 which shows the results for the Lag selection criteria for Brazil, Germany and Norway. It takes record of the Lag selection by the Akaike Information Criterion (AIC).

Table 16: Brazil Lag Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: BRAZILIR BRAZILLO BRAZILLIP BRAZILRSR
Exogenous variables: C
Sample: 2003M01 2013M10
Included observations: 124

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1384.188	NA	62231.74	22.39013	22.48110	22.42708
1	-805.5232	1110.663	7.124624	13.31489	13.76977	13.49967
2	-754.4575	94.71868	4.050453	12.74931	13.56811*	13.08193*
3	-739.0604	27.56576	4.098509	12.75904	13.94174	13.23948
4	-718.2462	35.92120	3.806966	12.68139	14.22800	13.30966
5	-695.0891	38.47063*	3.413117*	**12.56595***	14.47647	13.34205

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 17: Germany Lag Selection Criteria Results

VAR Lag Order Selection Criteria
Endogenous variables: GERMANYIR GERMANYLO GERMANYLIP GERMANYRSR
Exogenous variables: C
Sample: 2003M01 2013M10
Included observations: 124

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1466.948	NA	236443.7	23.72497	23.81595	23.76193
1	-777.3949	1323.498	4.526164	12.86121	13.31609	13.04599
2	-730.0468	87.82318	2.732201	12.35559	13.17438*	12.68821
3	-708.8093	38.02192	2.516081	12.27112	13.45382	12.75156
4	-677.6248	53.81842	1.977133*	12.02621	13.57281	12.65447*
5	-661.4704	26.83711*	1.984542	**12.02372***	13.93423	12.79981

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 18: Norway Lag Selection Criteria Results

VAR Lag Order Selection Criteria
Endogenous variables: NORWAYIR NORWAYLO NORWAYLIP
NORWAYRSR
Exogenous variables: C
Sample: 2003M01 2013M10
Included observations: 124

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1102.658	NA	663.6919	17.84932	17.94030	17.88628
1	-555.5977	1050.003	0.126502	9.283833	9.738717*	9.468618
2	-529.8296	47.79554	0.108154	9.126284	9.945076	9.458897*
3	-510.5710	34.47910*	0.102829*	**9.073726***	10.25643	9.554166
4	-499.2272	19.57722	0.111277	9.148826	10.69543	9.777094
5	-484.8240	23.92796	0.114894	9.174581	11.08509	9.950676

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Section II

Section II, shows the results of the Vector Autoregression Model (VAR) and Vecor Error Correction Model (VECM) for Brazil, Germany and Norway. The results are presented in tables 19, 20 and 21, respectively.

Table 19: Brazil Vector Error Correction Model

Vector Error Correction Estimates
Sample (adjusted): 2003M08 2013M10
Included observations: 123 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	CointEq2	CointEq3	
BRAZILIR_D(-1)	1.000000	0.000000	0.000000	
BBRAZILLO_D(-1)	0.000000	1.000000	0.000000	
BRAZILLIP_D(-1)	0.000000	0.000000	1.000000	
BRAZIL_RSR(-1)	0.014863	9.09E-05	-0.000308	
	(0.00251)	(7.5E-05)	(5.0E-05)	
	[5.91130]	[1.21708]	[-6.13316]	
C	-17.42211	-14.70480	-4.679514	
Error Correction:	**D(IR_D)**	**D(LO_D)**	**D(LIP_D)**	**D(RSR)**
CointEq1	-0.040399	-0.005415	-0.001694	-391.0543
	(0.01652)	(0.00445)	(0.00081)	(158.290)
	[-2.44494]	[-1.21705]	[-2.09587]	[-2.47049]
CointEq2	0.120544	-0.068065	-0.000463	-3151.712
	(0.09426)	(0.02538)	(0.00461)	(902.947)
	[1.27891]	[-2.68190]	[-0.10039]	[-3.49047]
CointEq3	-1.925263	-0.262616	-0.102501	-14988.25
	(0.78582)	(0.21159)	(0.03845)	(7527.98)
	[-2.45000]	[-1.24115]	[-2.66587]	[-1.99101]
D(BRAZILIR_D(-1))	0.271858	-0.008789	-0.001618	-171.4814
	(0.09454)	(0.02546)	(0.00463)	(905.693)
	[2.87552]	[-0.34525]	[-0.34973]	[-0.18934]
D(BRAZILIR_D(-2))	0.271852	0.026278	-0.002689	-390.4858
	(0.08925)	(0.02403)	(0.00437)	(855.007)
	[3.04592]	[1.09346]	[-0.61583]	[-0.45670]
D(BRAZILIR_D(-3))	0.189152	0.005849	0.005539	378.1826
	(0.08905)	(0.02398)	(0.00436)	(853.096)
	[2.12407]	[0.24392]	[1.27122]	[0.44331]
D(BRAZILIR_D(-4))	0.049428	-0.001691	0.000365	356.5933
	(0.08853)	(0.02384)	(0.00433)	(848.069)
	[0.55834]	[-0.07093]	[0.08420]	[0.42048]

D(BRAZILIR_D(-5))	0.052261	0.000212	0.003369	738.7563
	(0.08480)	(0.02283)	(0.00415)	(812.347)
	[0.61630]	[0.00928]	[0.81203]	[0.90941]
D(BBRAZILLO_D(-1))	-0.218151	0.636521	0.038215	1138.504
	(0.35450)	(0.09545)	(0.01735)	(3396.06)
	[-0.61537]	[6.66833]	[2.20319]	[0.33524]
D(BBRAZILLO_D(-2))	0.563443	-0.148495	-0.015213	-3391.842
	(0.43163)	(0.11622)	(0.02112)	(4134.91)
	[1.30539]	[-1.27769]	[-0.72036]	[-0.82029]
D(BBRAZILLO_D(-3))	0.034803	0.243591	-0.015300	1978.089
	(0.42867)	(0.11542)	(0.02097)	(4106.56)
	[0.08119]	[2.11039]	[-0.72944]	[0.48169]
D(BBRAZILLO_D(-4))	0.594405	-0.026814	0.053429	-10.12941
	(0.42288)	(0.11386)	(0.02069)	(4051.05)
	[1.40562]	[-0.23549]	[2.58228]	[-0.00250]
D(BBRAZILLO_D(-5))	-0.170653	0.041337	-0.041285	3471.648
	(0.37103)	(0.09991)	(0.01815)	(3554.43)
	[-0.45994]	[0.41376]	[-2.27412]	[0.97671]
D(BRAZILLIP_D(-1))	4.743252	0.151081	-0.154174	16676.01
	(1.88071)	(0.50640)	(0.09202)	(18016.7)
	[2.52206]	[0.29834]	[-1.67543]	[0.92558]
D(BRAZILLIP_D(-2))	2.872622	0.020511	0.004633	8825.583
	(1.79548)	(0.48345)	(0.08785)	(17200.2)
	[1.59992]	[0.04243]	[0.05273]	[0.51311]
D(BRAZILLIP_D(-3))	5.191752	0.016945	-0.177072	4550.449
	(1.80217)	(0.48526)	(0.08818)	(17264.4)
	[2.88084]	[0.03492]	[-2.00812]	[0.26357]
D(BRAZILLIP_D(-4))	5.529539	-0.421597	-0.215805	-36535.50
	(1.77910)	(0.47904)	(0.08705)	(17043.4)
	[3.10805]	[-0.88008]	[-2.47911]	[-2.14368]
D(BRAZILLIP_D(-5))	1.671235	0.037643	0.064003	3758.012
	(1.86607)	(0.50246)	(0.09130)	(17876.5)
	[0.89559]	[0.07492]	[0.70098]	[0.21022]
D(BRAZIL_RSR(-1))	1.76E-06	6.13E-07	-6.58E-06	0.522560
	(2.6E-05)	(6.9E-06)	(1.3E-06)	(0.24641)
	[0.06851]	[0.08850]	[-5.22460]	[2.12073]
D(BRAZIL_RSR(-2))	-5.85E-06	1.91E-06	-5.11E-06	0.422040
	(2.4E-05)	(6.3E-06)	(1.2E-06)	(0.22546)
	[-0.24839]	[0.30152]	[-4.43894]	[1.87189]
D(BRAZIL_RSR(-3))	-8.00E-06	1.41E-07	-3.56E-06	0.390213
	(2.0E-05)	(5.4E-06)	(9.9E-07)	(0.19298)
	[-0.39728]	[0.02600]	[-3.61441]	[2.02206]
D(BRAZIL_RSR(-4))	-3.65E-06	-5.72E-06	-3.24E-06	0.314811
	(1.6E-05)	(4.3E-06)	(7.9E-07)	(0.15436)
	[-0.22677]	[-1.31818]	[-4.11169]	[2.03952]

D(BRAZIL_RSR(-5))	1.46E-07	-6.15E-06	-1.09E-06	0.191730
	(1.2E-05)	(3.1E-06)	(5.7E-07)	(0.11107)
	[0.01261]	[-1.96934]	[-1.91883]	[1.72625]
C	-0.057499	0.008990	0.003913	159.3995
	(0.03409)	(0.00918)	(0.00167)	(326.598)
	[-1.68655]	[0.97927]	[2.34579]	[0.48806]
R-squared	0.680157	0.517871	0.450739	0.531661
Adj. R-squared	0.605850	0.405861	0.323133	0.422854
Sum sq. resids	10.13221	0.734608	0.024257	9.30E+08
S.E. equation	0.319915	0.086141	0.015653	3064.712
F-statistic	9.153342	4.623442	3.532264	4.886311
Log likelihood	-20.99688	140.3876	350.1420	-1148.588
Akaike AIC	0.731657	-1.892482	-5.303121	19.06647
Schwarz SC	1.280375	-1.343763	-4.754402	19.61519
Mean dependent	-0.135894	0.010833	0.002276	10.58407
S.D. dependent	0.509570	0.111755	0.019026	4034.103

Determinant resid covariance (dof adj.)	1.661508
Determinant resid covariance	0.697305
Log likelihood	-675.9450
Akaike information criterion	12.74707
Schwarz criterion	15.21631

Table 20: Germany Vector Auto regression Estimates

Vector Autoregression Estimates
Sample (adjusted): 2003M07 2013M10
Included observations: 124 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	IR_D	LO_D	LIP_D	RSR_D
GERMANYIR_D(-1)	1.625353	1.113820	0.026892	595.4210
	(0.10197)	(1.96361)	(0.01196)	(281.995)
	[15.9398]	[0.56723]	[2.24774]	[2.11146]
GERMANYIR_D(-2)	-0.898239	1.454224	0.000599	-840.7004
	(0.18903)	(3.64010)	(0.02218)	(522.757)
	[-4.75192]	[0.39950]	[0.02700]	[-1.60821]
GERMANYIR_D(-3)	0.291970	-5.411034	-0.024597	80.41740
	(0.20244)	(3.89842)	(0.02375)	(559.855)
	[1.44225]	[-1.38801]	[-1.03554]	[0.14364]
GERMANYIR_D(-4)	-0.092905	6.917524	-0.026971	103.1046
	(0.19138)	(3.68551)	(0.02246)	(529.279)
	[-0.48544]	[1.87695]	[-1.20107]	[0.19480]
GERMANYIR_D(-5)	0.077053	-4.236895	0.022031	14.39503
	(0.10998)	(2.11795)	(0.01290)	(304.161)
	[0.70059]	[-2.00047]	[1.70722]	[0.04733]
GERMANYLOOD(-1)	-0.012211	0.734280	-0.002315	6.546793
	(0.00487)	(0.09385)	(0.00057)	(13.4773)

	[-2.50568]	[7.82432]	[-4.04789]	[0.48577]
GERMANYLOOD(-2)	0.009406	0.282077	0.000782	2.872730
	(0.00593)	(0.11424)	(0.00070)	(16.4065)
	[1.58549]	[2.46911]	[1.12394]	[0.17510]
GERMANYLOOD(-3)	0.008708	0.461909	0.001954	-13.07651
	(0.00544)	(0.10484)	(0.00064)	(15.0558)
	[1.59950]	[4.40596]	[3.05919]	[-0.86854]
GERMANYLOOD(-4)	-0.008330	-0.518895	0.000628	-7.896254
	(0.00588)	(0.11321)	(0.00069)	(16.2580)
	[-1.41701]	[-4.58353]	[0.91001]	[-0.48569]
GERMANYLOOD(-5)	-0.000993	-0.001595	-0.001275	14.73019
	(0.00464)	(0.08935)	(0.00054)	(12.8310)
	[-0.21410]	[-0.01785]	[-2.34273]	[1.14801]
GERMANYLIP_D(-1)	2.040297	-8.507258	0.664838	-1065.921
	(0.83840)	(16.1450)	(0.09837)	(2318.60)
	[2.43358]	[-0.52693]	[6.75853]	[-0.45973]
GERMANYLIP_D(-2)	0.123879	2.044752	0.300228	-1175.869
	(1.00055)	(19.2676)	(0.11740)	(2767.04)
	[0.12381]	[0.10612]	[2.55740]	[-0.42496]
GERMANYLIP_D(-3)	-1.905228	43.86730	0.066599	1260.406
	(0.97272)	(18.7318)	(0.11413)	(2690.08)
	[-1.95866]	[2.34187]	[0.58353]	[0.46854]
GERMANYLIP_D(-4)	0.917761	4.923645	0.071032	179.8591
	(1.00200)	(19.2957)	(0.11757)	(2771.06)
	[0.91593]	[0.25517]	[0.60418]	[0.06491]
GERMANYLIP_D(-5)	-0.463146	-36.05819	-0.093714	-121.2696
	(0.81651)	(15.7236)	(0.09580)	(2258.07)
	[-0.56723]	[-2.29326]	[-0.97820]	[-0.05370]
GERMANY_RSR(-1)	7.30E-05	-0.002525	-2.53E-06	0.056727
	(3.6E-05)	(0.00069)	(4.2E-06)	(0.09879)
	[2.04291]	[-3.66985]	[-0.60472]	[0.57420]
GERMANY_RSR(-2)	1.16E-06	-0.001042	5.22E-06	-0.170997
	(3.9E-05)	(0.00074)	(4.5E-06)	(0.10698)
	[0.02999]	[-1.39853]	[1.14939]	[-1.59847]
GERMANY_RSR(-3)	4.05E-05	-8.01E-05	-2.27E-06	-0.001057
	(3.9E-05)	(0.00076)	(4.6E-06)	(0.10861)
	[1.03054]	[-0.10588]	[-0.49256]	[-0.00973]
GERMANY_RSR(-4)	7.70E-05	0.000197	7.61E-06	0.057180
	(3.8E-05)	(0.00072)	(4.4E-06)	(0.10407)
	[2.04674]	[0.27237]	[1.72424]	[0.54942]
GERMANY_RSR(-5)	1.97E-07	-0.001174	1.00E-05	-0.107945
	(3.9E-05)	(0.00075)	(4.6E-06)	(0.10730)
	[0.00508]	[-1.57067]	[2.20335]	[-1.00597]
C	-2.961486	-23.67514	-0.010909	4082.996

	(1.18242)	(22.7700)	(0.13874)	(3270.02)
	[-2.50459]	[-1.03975]	[-0.07863]	[1.24862]
R-squared	0.994595	0.985656	0.975779	0.174105
Adj. R-squared	0.993546	0.982871	0.971076	0.013737
Sum sq. resids	1.364166	505.8807	0.018780	10433299
S.E. equation	0.115084	2.216182	0.013503	318.2674
F-statistic	947.6781	353.8976	207.4780	1.085657
Log likelihood	103.6554	-263.1216	369.3566	-879.0427
Akaike AIC	-1.333151	4.582606	-5.618654	14.51682
Schwarz SC	-0.855523	5.060234	-5.141026	14.99445
Mean dependent	2.100565	104.6910	4.605524	46.74919
S.D. dependent	1.432467	16.93339	0.079397	320.4762
Determinant resid covariance (dof adj.)		1.061390		
Determinant resid covariance		0.505286		
Log likelihood		-661.4704		
Akaike information criterion		12.02372		
Schwarz criterion		13.93423		

Table 21: Norway Vector Auto regression Estimates

Vector Autoregression Estimates
Sample (adjusted): 2003M05 2013M10
Included observations: 126 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	NORWAYIR_D	NORWAYLO_D	NORWAYLIP_D	NORWAY_RSR
NORWAYIR_D(-1)	1.116783	0.046375	0.010480	2.522202
	(0.09172)	(1.40054)	(0.00511)	(6.53838)
	[12.1758]	[0.03311]	[2.05070]	[0.38575]
NORWAYIR_D(-2)	0.092900	1.901493	-0.002818	-9.907042
	(0.14126)	(2.15701)	(0.00787)	(10.0700)
	[0.65764]	[0.88154]	[-0.35800]	[-0.98382]
NORWAYIR_D(-3)	-0.276712	-1.793634	-0.007557	2.324385
	(0.08725)	(1.33218)	(0.00486)	(6.21928)
	[-3.17165]	[-1.34639]	[-1.55470]	[0.37374]
NORWAYLO_D(-1)	0.002090	0.965314	8.60E-05	-0.928643
	(0.00609)	(0.09293)	(0.00034)	(0.43384)
	[0.34337]	[10.3875]	[0.25359]	[-2.14050]
NORWAYLO_D(-2)	0.005512	0.058279	-0.000495	0.197841
	(0.00848)	(0.12949)	(0.00047)	(0.60452)
	[0.64997]	[0.45007]	[-1.04803]	[0.32727]
NORWAYLO_D(-3)	-0.011051	-0.037896	0.000494	0.589009
	(0.00615)	(0.09397)	(0.00034)	(0.43871)
	[-1.79564]	[-0.40326]	[1.44118]	[1.34258]
NORWAYLIP_D(-1)	2.334155	11.92948	0.471193	-0.741960
	(1.67361)	(25.5550)	(0.09325)	(119.303)
	[1.39469]	[0.46682]	[5.05318]	[-0.00622]

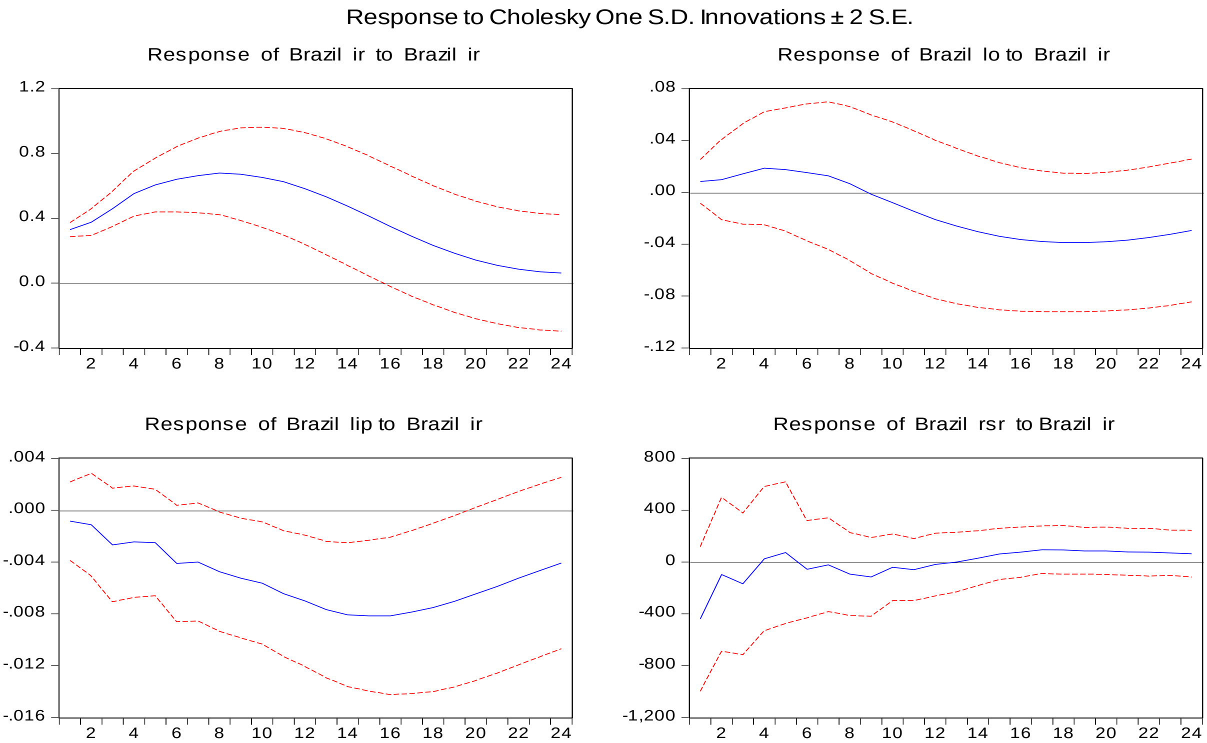
NORWAYLIP_D(-2)	1.011337	18.22886	0.258446	-142.5195
	(1.78452)	(27.2486)	(0.09943)	(127.210)
	[0.56673]	[0.66898]	[2.59937]	[-1.12035]
NORWAYLIP_D(-3)	-1.155279	-21.33668	0.215243	191.6472
	(1.71189)	(26.1395)	(0.09538)	(122.032)
	[-0.67486]	[-0.81626]	[2.25669]	[1.57047]
NORWAY_RSR(-1)	0.000230	0.054034	0.000127	0.260700
	(0.00140)	(0.02145)	(7.8E-05)	(0.10013)
	[0.16402]	[2.51932]	[1.62389]	[2.60363]
NORWAY_RSR(-2)	0.000356	0.035351	-5.50E-05	-0.107272
	(0.00145)	(0.02216)	(8.1E-05)	(0.10346)
	[0.24510]	[1.59522]	[-0.68032]	[-1.03688]
NORWAY_RSR(-3)	0.001815	0.020588	9.08E-05	0.052061
	(0.00140)	(0.02138)	(7.8E-05)	(0.09980)
	[1.29649]	[0.96310]	[1.16465]	[0.52166]
C	-9.586020	-39.19433	0.248788	-185.8994
	(4.33084)	(66.1293)	(0.24130)	(308.724)
	[-2.21343]	[-0.59269]	[1.03104]	[-0.60215]
R-squared	0.969016	0.989891	0.957583	0.260545
Adj. R-squared	0.965725	0.988818	0.953078	0.182018
Sum sq. resids	7.760657	1809.430	0.024091	39436.09
S.E. equation	0.262066	4.001582	0.014601	18.68133
F-statistic	294.5022	922.0988	212.5844	3.317931
Log likelihood	-3.191718	-346.6488	360.6314	-540.7940
Akaike AIC	0.257011	5.708712	-5.517959	8.790381
Schwarz SC	0.549644	6.001344	-5.225327	9.083013
Mean dependent	3.095873	148.0509	4.688468	3.085714
S.D. dependent	1.415548	37.84097	0.067407	20.65551

Determinant resid covariance (dof adj.)	0.069611
Determinant resid covariance	0.045031
Log likelihood	-519.8192
Akaike information criterion	9.076495
Schwarz criterion	10.24702

Section III

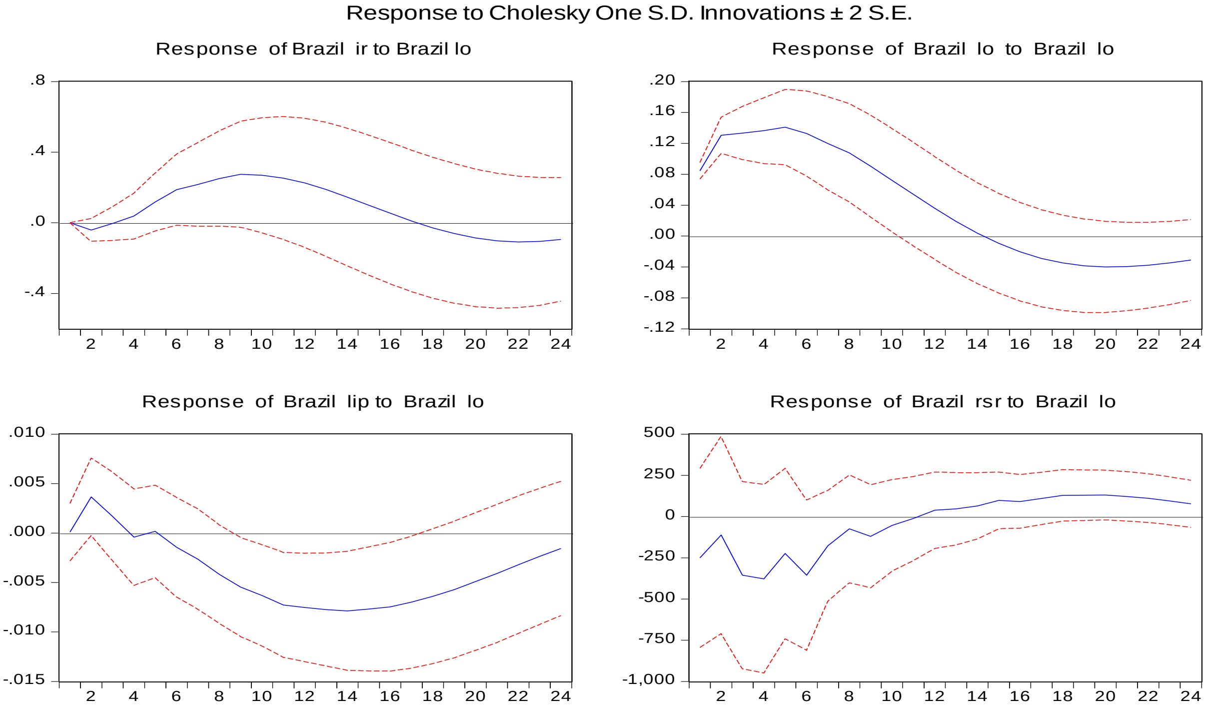
This section i.e., Figure 5 to 16, show the impulse responses function for Brazil, Germany and Norway's variables i.e. change in interest rate (Δir), changes in real oil prices (Δlo), changes in industrial production (Δlip) and real stock return (rsr) and how they react to each other. Note that the ordering of the variables followed Sardosky's suggestions while looking at 24 months into the future.

Figure 5: Response to Brazil interest rates shocks



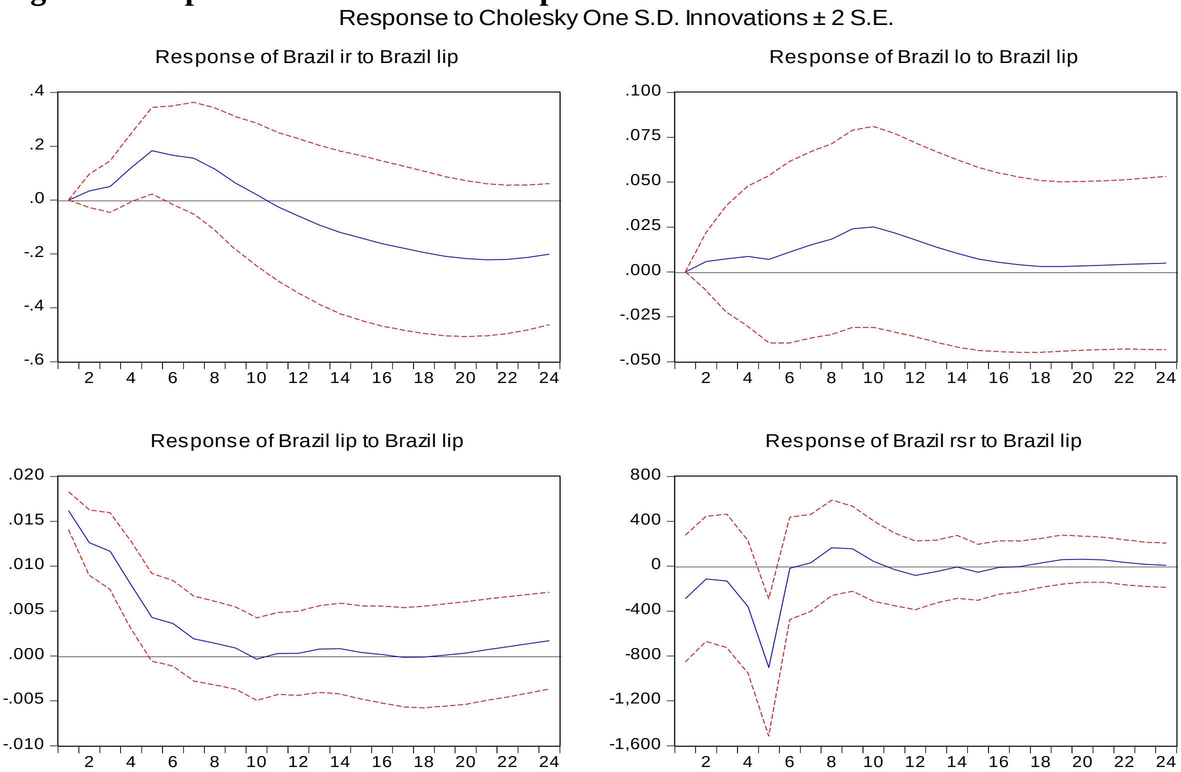
Source Eviews

Figure 6: Response to Brazil real oil price shocks



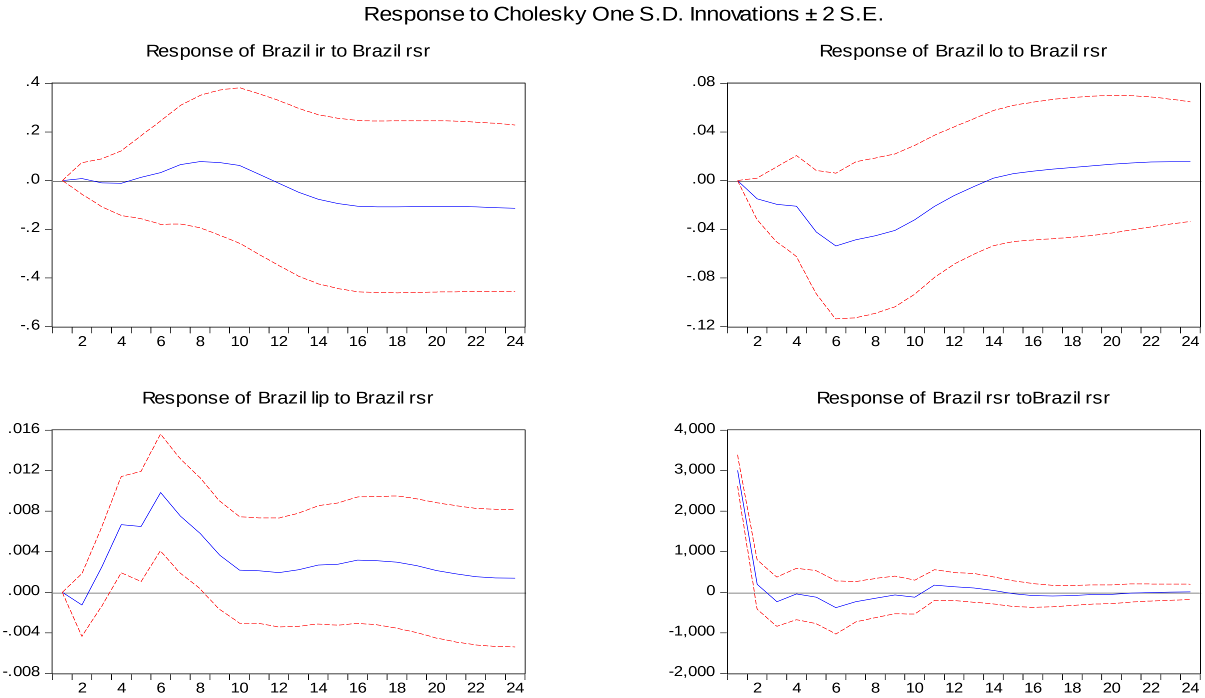
Source Eviews

Figure 7: Response to Brazil industrial production shocks



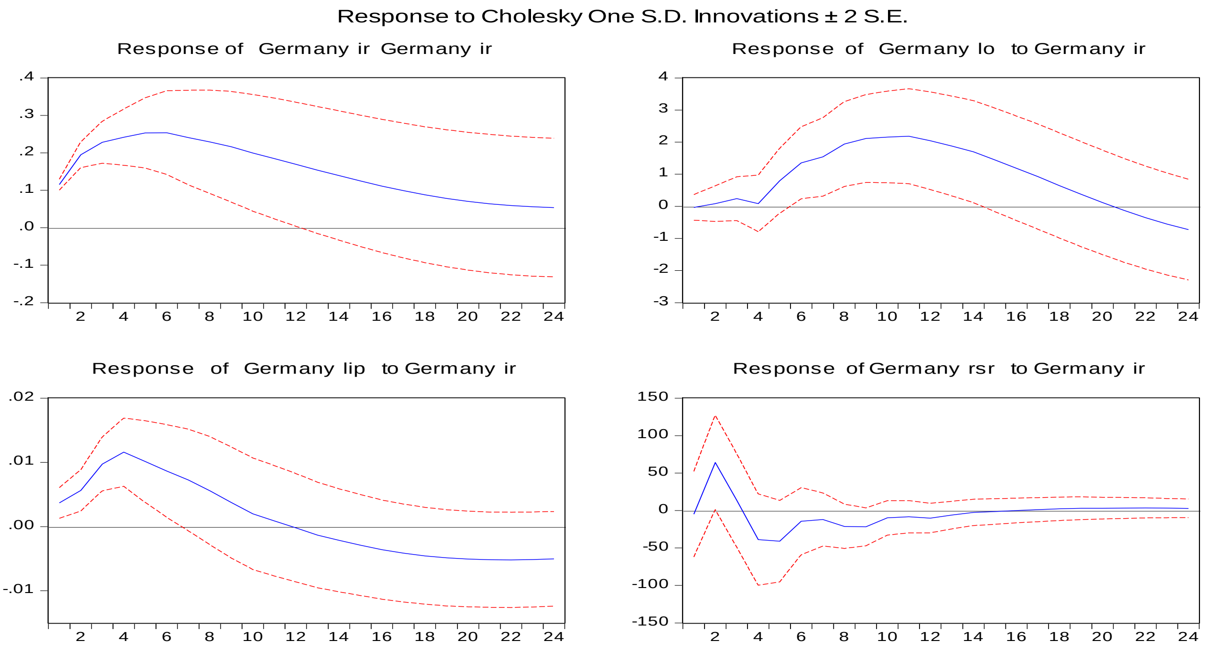
Source Eviews

Figure 8: Response to Brazil real stock return shocks



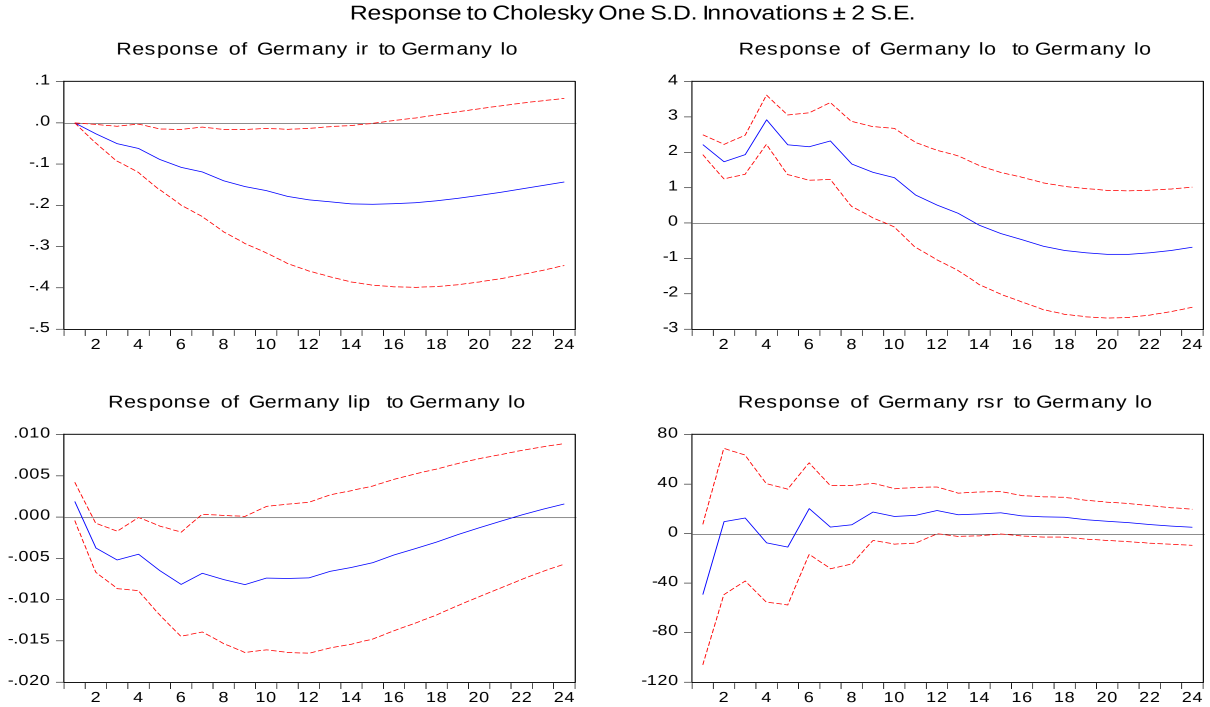
Source Eviews

Figure 9: Response to Germany interest rate shocks



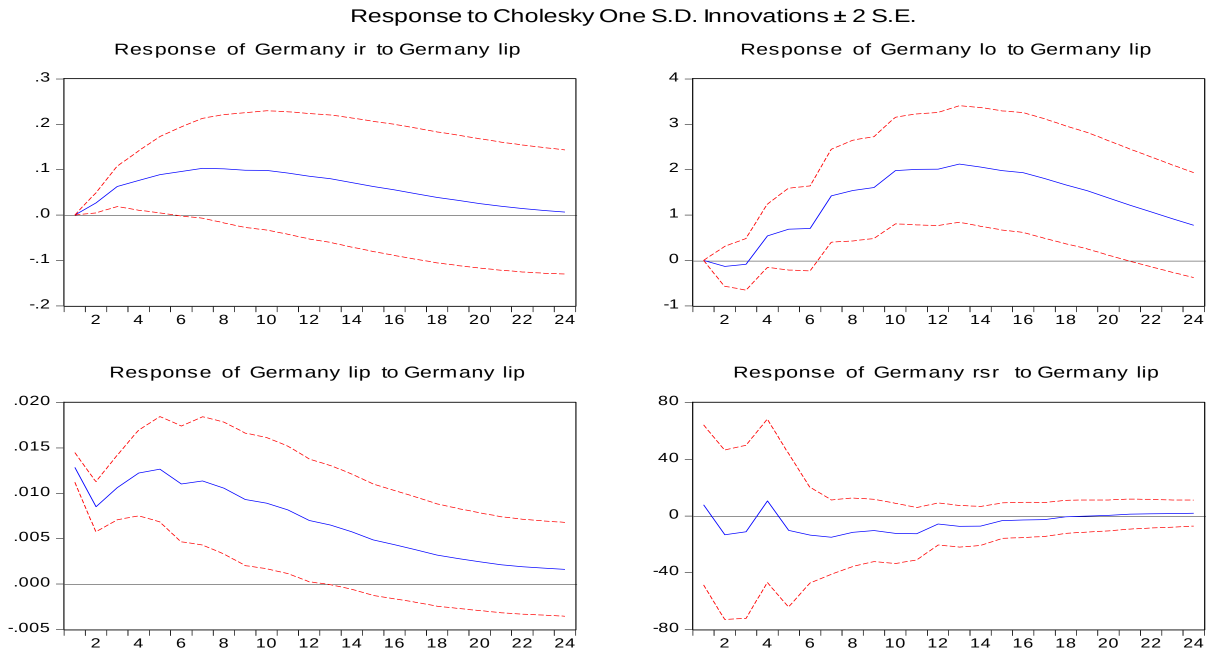
Source Eviews

Figure 10: Response to Germany real oil price shocks



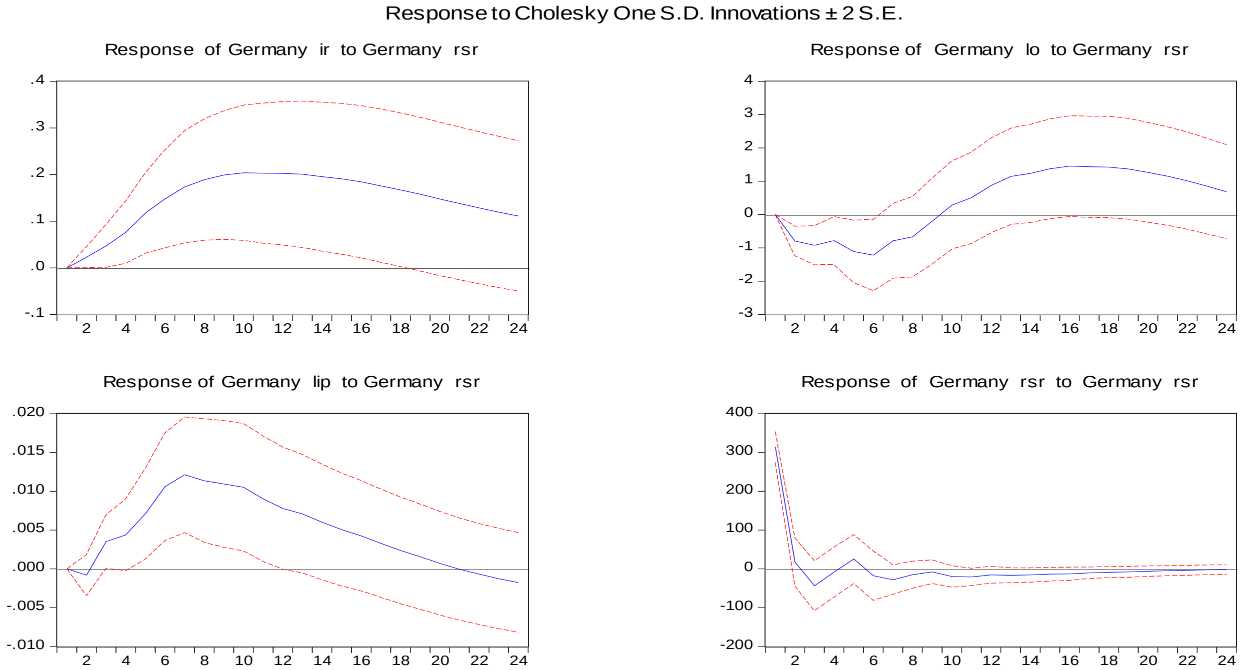
Source Eviews

Figure 11: Response to Germany industrial production shocks



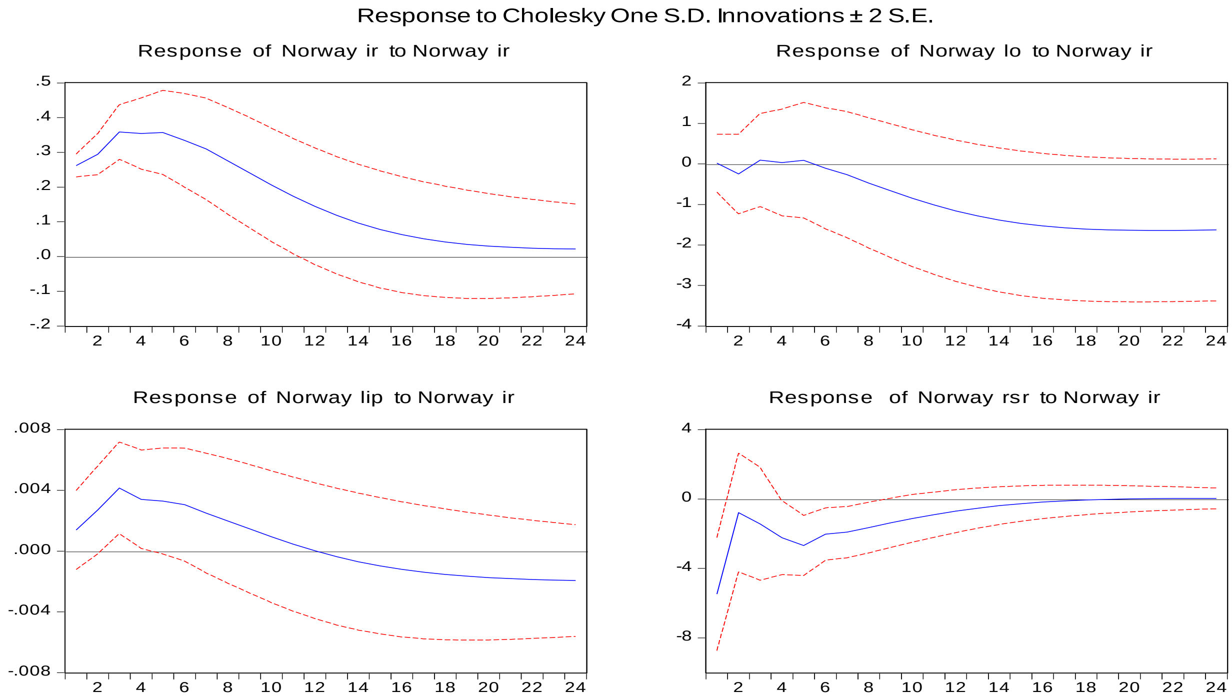
Source Eviews

Figure 12: Response to Germany real stock return shocks



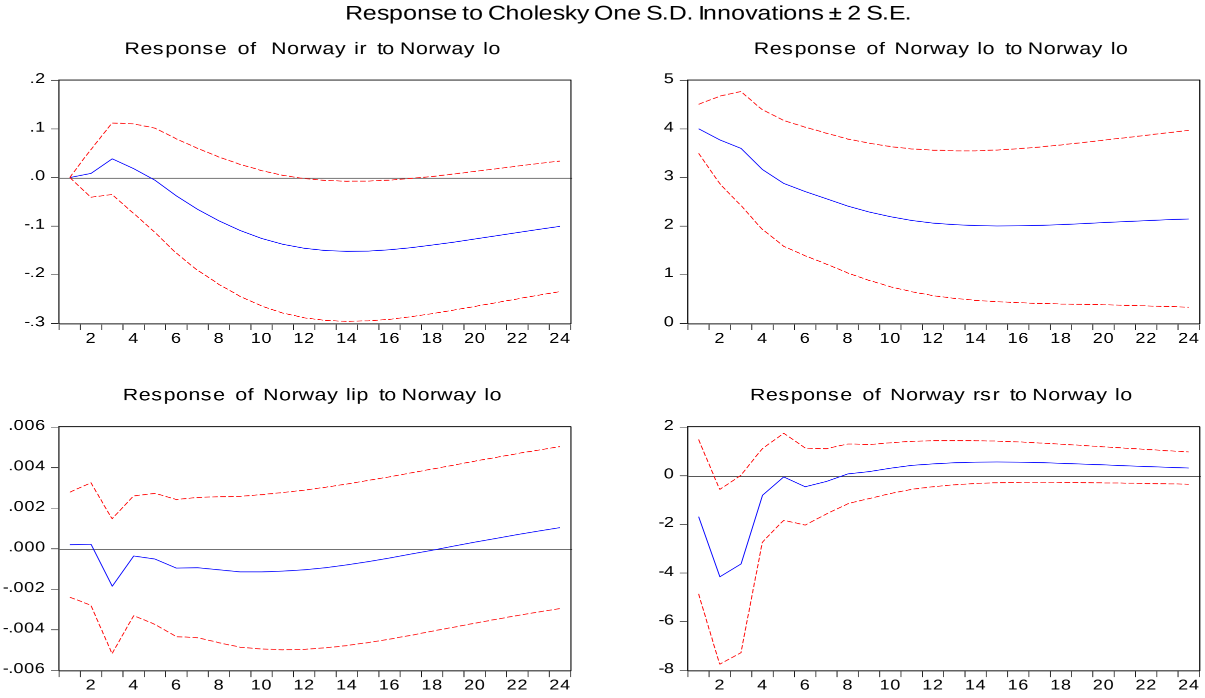
Source Eviews

Figure 13: Response to Norway interest rate shocks



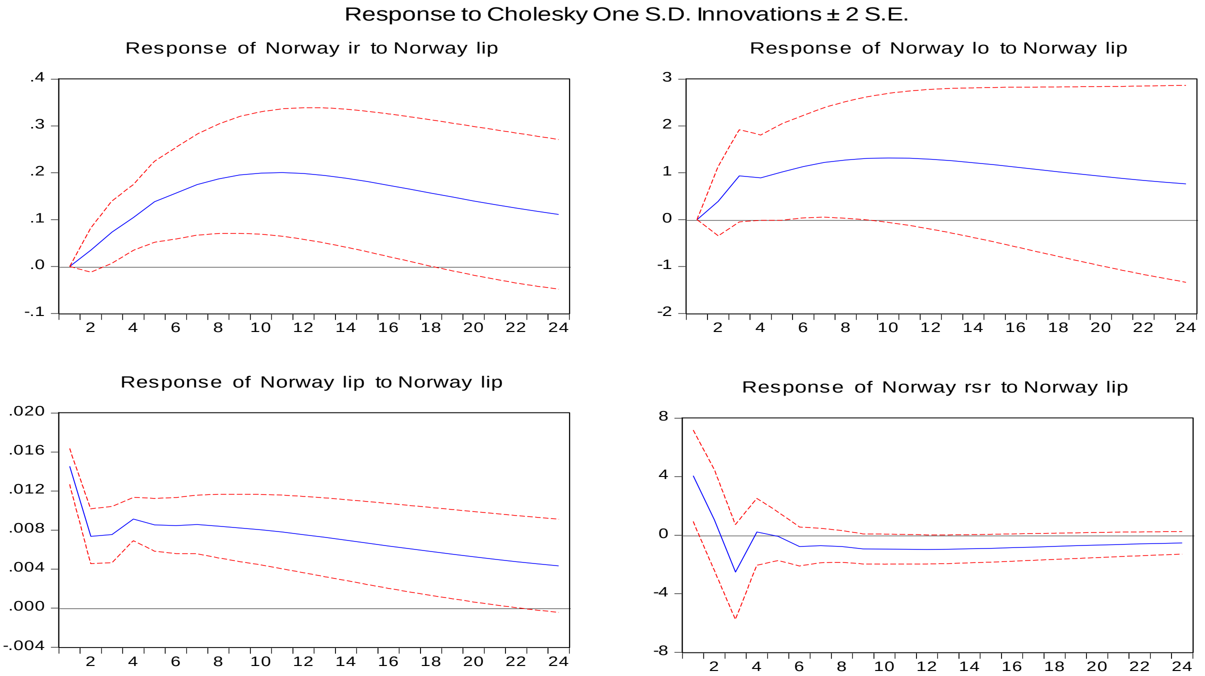
Source Eviews

Figure 14: Response to Norway real oil price shocks



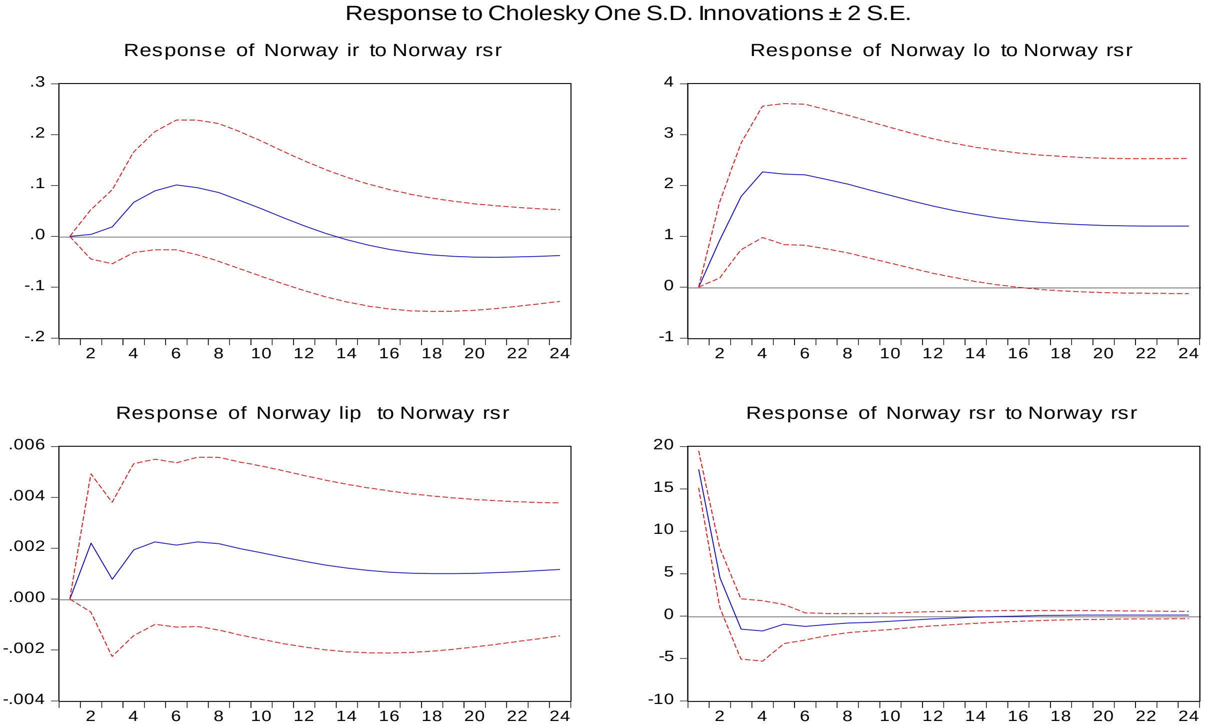
Source Eviews

Figure 15: Response to Norway industrial production shocks



Source Eviews

Figure 16: Response to Norway real stock returns shocks



Source Eviews